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EDITED BY J. MCKEEN CATTELL

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RECENT BOOKS OF SCIENTIFIC INTEREST

The Theory of Light. THOMAS PRESTON. Fifth edition, edited by ALFRED W. PORTER. 643 pp. $8.00. London, 1928.

The whole of this standard treatment has been revised with a view to bringing it thoroughly up-to-date and also to coordinating and consolidating the work of the editors of previous editions.

The Quantum and its Interpretation. H. STANLEY ALLEN. 274 pp. 30 figures. $4.00. New York, 1928.

Emphasis is placed on the magnetic aspect of the interpretation of the Quantum, and a middle course is steered between a mathematical and a purely descriptive treatment. The plan of organization and the detailed description of fundamental principles makes this work suitable for advanced text or reference use.

Practical Television. E. T. LARNER. 175 pp. Illustrated. $3.75. New York, 1928.

In the present work the author deals very fully with the fundamental principles from which television was developed, and deals with them in such a way as to interest the general reader without departing from strict scientific accuracy.

Problèmes et Calculs de Chimie générale. Recueil destiné aux Élèves des grandes Écoles et aux Étudiants en Chimie. R. HOCART. 182 pp. Paper bound. $1.20. Paris. Gauthier-Villars. 1928.

This outline attempts by means of various examples to illustrate some of the most important ideas of general chemistry, and to assist the reader to solve problems which present themselves in the laboratory during the study of chemical reactions.

An Elementary Manual of Physiology. For colleges, schools of nursing, of physical education, and of the practical arts. RUSSELL BURTON-OPITZ. Third revised edition. 419 pp. Illustrated. $2.50. Philadelphia, 1928.

This work is a reflection of Dr. Burton-Opitz's successful teaching at Columbia University, New York City. The fundamental principles are described in detail and the application of these principles is given clearly and definitely.

Elementary Bacteriology. JOSEPH E. GREAVES. 506 pp. 129 illustrations. $3.50. Philadelphia, 1928.

This new work discusses theories, the work of the pioneers, discovery of bacteriology, actual study of bacteria—classification, form, chemistry, food requirements, products, etc. Over one half of the book is devoted to a discussion of the part bacteria play in the world of man.

The Surgical Operations of President Cleveland in 1893. Together with six additional papers of reminiscences. WILLIAM W. KEEN. 251 pp. $1.50. Philadelphia, 1928.

Dr. Keen reveals in his book the unusual circumstances, the unique place where the operations were performed and the instrument used. He and his colleagues completed the work in a month's time without trace of scar.

Das Wesen der Heilkunst. Grundlagen einer Philosophie der Medizin. HANS MUCH. 234 pp. $2.88. Darmstadt. Otto Reichl Verlag. 1928.

Professor Hans Much is the editor of a new series entitled: "Philosophy of Medicine" and the above is the first volume issued in this series. His aim is the reformation of medicine as taught and practised to-day.

Hamburgs Vogelwelt. Unter Berücksichtigung der benachbarten Gebiete, nämlich von Schleswig-Holstein, Hannover, Braunschweig, Oldenburg, Bremen und Westfalen. PROFESSOR DR. FR. DIETRICH. 398 pp. $2.16. Hamburg. Otto Meissners Verlag. 1928.

This is the first book on the avifauna of the City of Hamburg and surrounding territory. It is the outcome of the author's contributions to this particular section of a hand list of German birds, begun in 1913, but never published.

Die Stellung des Menschen im Kosmos. MAX SCHELER. 115 pp. Paper bound. $1.44. Darmstadt. Otto Reichl Verlag. 1928.

The author gives here in very compact form the principal points of his philosophical anthropology. The volume represents the results of investigations carried on by Scheler for a number of years and frequently embodied in the lectures delivered by him since 1922.

Ralph Waldo Emersons Geisteswelt. DR. PAUL SAKMANN. xvi + 256 pp. $1.68. (Volume 27 of Frommanns Klassiker der Philosophie) Stuttgart, Fr. Frommanns Verlag (H. Kurtz). 1928.

As the first one in German language this biography makes use of the "Journals" published in 1914. It shows the spiritual connection between Emerson and the Germanic Europe and thus builds "the very best bridge between those two peoples who have most to give to each other."

The Sanctity of Law. JOHN W. BURGESS. 345 pp. $3.50. New York, 1928.

"The Sanctity of Law" by John W. Burgess is a history of law from the beginning. It is in the nature of a political scientist's plea for unselfish determination of international needs and necessities on the basis of reason and justice.

Aptitude Testing. CLARK L. HULL. 535 pp. $2.68. Yonkers, New York, 1928.

In part one of this book scholastic, vocational, temperamental, sensory and motor, and other types of tests are discussed and many topics of general interest are included. Part two deals with the technique of test construction.

Vestiges of Pre-metric Weights and Measures Persisting in Metric-System Europe 1926–1927. ARTHUR E. KENNELLY. 189 pp. $2.50. New York, 1928.

This book represents a year's research on this subject, conducted personally by the author, in a number of European countries, for the purpose of finding how numerous or important the vestiges of old units might be in commerce and business.

 (*See page x.*)

THE SCIENTIFIC MONTHLY

OCTOBER, 1928

THE FORMATION OF CORAL REEFS

By Professor W. M. DAVIS

Distribution of Coral Reefs

Coral reefs are rocky structures formed of the calcareous framework of various marine organisms, both animals and plants, among which the colonial polyps, known as corals, and the lime-secreting algae, known as nullipores, are by far the most important. These reef-builders flourish only in the warmer oceans and at moderate depths, the nullipores usually not below fifty fathoms and the corals not below twenty or twenty-five fathoms. In the torrid Pacific, cool currents from the south and north exclude reef-builders from the eastern third of the ocean; the middle and western thirds constitute the great coral sea of the world. In the torrid Atlantic similar cool currents reduce nearly the whole breadth of the surface waters below a temperature sufficient for the formation of reefs, which are therefore found in this ocean only along parts of the Brazilian coast and in the West Indies; the outlying reefs of Bermuda are as exceptional as is the great current of warm water, commonly known as the Gulf Stream, which permits them. Only in the Indian Ocean are the surface waters warm enough for reef-builders across the whole stretch of its torrid belt from Africa to Australia, evidently because Australia, unlike South America, does not reach south far enough to divert a great current of cold water toward the equator; but as islands are few in the eastern Indian Ocean reefs also are few there.

The minute larval forms of corals and the still more minute spores of nullipores are given off in myriads by the adult forms, and are drifted passively in ocean currents, where most of them are "food for fishes." If they happen to be carried to a reefless shore of firm rock or to a shallow bank where pebbles or shells lie undisturbed by waves in water of fitting temperature, they may there attach themselves, and by growing, multiplying and spreading, in time form a new reef. The living forms are vari-colored; their calcareous frame work is white; the reefrock is gray. The flat upper surface of a reef, lying close to sea-level, is narrow in the early stages of its formation, but it may later widen to half a mile or more. The flat is in some cases covered with reef-builders; in other cases it is almost barren. The outer face of the reef may either fall off abruptly, or may slope gradually to forty of fifty fathoms and then pitch steeply to great oceanic depths. It is chiefly on the upper part of the gentle slope, the so-called "growing face," that reef-builders flourish best. There, under the almost ceaseless beating of the trade-wind surf, the smooth, cloak-like nullipores serve an important part in binding together the more salient and less continuous coral growths. Darwin long ago noted that certain reefs are "protected by a . . . thick growth of Nulliporae on the outer margin, the part most exposed to the breakers, and this must effectually aid in preserving it

from being worn down." Nevertheless, blocks and fragments of reefrock, detached from the growing face by storm waves, are not infrequently thrown back on the reef flat, or shifted forward down the frontal slope until they come to the steep pitch where they descend to deeper water. The steep pitch may therefore be regarded as of talus-like origin.

Fringing Reefs

Coral reefs are of three kinds: fringes, barriers and atolls. Fringing reefs are sea-level flats, commonly from a quarter to half a mile wide, attached to the salient parts of continental or insular coasts, with their sea face falling off rather abruptly to moderate or greater depths. They are less developed in coastal reentrants, where turbid fresh water is delivered by stream floods; and they can not grow at all on sandy or muddy, bay-head deltas which, as they advance, may smother previously formed fringes. Reefs of this kind, openly exposed to ocean surf, are abundantly developed in the East Indies.

Barrier Reefs

Barrier reefs (Fig. 1), have, like fringing reefs, a narrow or broad flat and an outer growing face, but they are separated from the coast that they front by a smooth-floored, salt-water lagoon, from half a mile to a score of miles or more in width, and commonly from ten or twenty to forty fathoms in depth. Thus barriers have not only an outer face toward the open ocean, where the reef-builders grow most vigorously, but also an inner face toward the lagoon, where more delicately branching forms

Fig. 1. Tahaa, a maturely dissected and well embayed volcanic island in the Society group, encircled by a barrier reef. From a Hydrographic Office Chart. A heavy line is added, back of the lagoon shore line, to show the very irregular initial shore line of subsidence, before partial bay-filling by deltas had taken place.

are found, if they are not overwhelmed by detrital inwash. The lagoon floor is usually rather smoothly strewn over with fine reef sand or silt, with detritus washed out from the coast, or with the remains of organisms growing in the lagoon waters or on the lagoon floor; indeed, the floor is sometimes covered with nullipores (Halimeda) which form a thick mat that has been compared to a peat bog. The inner shore of the lagoon is commonly occupied by a fringing reef, which is enclosed from the outer waves by the barrier reef. The growth of enclosed fringes is, however, not so vigorous as that of exposed fringes.

Barrier reefs are frequently interrupted by passages or "passes," through which ocean-going vessels may enter the lagoon. In narrow-lagoon barriers the passes usually lie opposite shore reentrants, as if in some way determined by the outwash of coastal streams. In wide-lagoon barriers, the passes on the windward side of an island-encircling reef are fewer in number than the reentrants of the shore, as if some passes that had originally existed had been closed by the reef-builders, for it seems to be on this arc of the reef that an abundant supply of dissolved oxygen and of food (plankton), brought by the wind-driven ocean waters, permits the most active reef growth. On the leeward side of such a reef circuit, the passes often open into broad breaches, presumably because of the unfavorable conditions there produced by the leeward drift of lagoon-floor sediments; for when the usually clear lagoon waters are agitated by storm winds, they become turbid, and at such times a considerable quantity of fine sediment is drifted out through the breaches into the open ocean.

The Great Barrier Reef of Australia

The longest barrier in the world is the Great Barrier Reef of the northeastern or Queensland coast of Australia. The patches and thickets of corals of this immense reef are finely illustrated in Kent's volume on the huge structure.[1] It is nine hundred nautical miles in length, with a lagoon from thirty to seventy miles in width, but of ordinary depth. Many small and large islands, the larger ones having well-embayed shores, rise from the lagoon of this enormous natural breakwater. The exposed outer side of the lagoon islands is relatively little cliffed, and the well-embayed coast of the mainland is not cliffed at all; this indicates a long-continued protection of the coast by the growing reef. But farther south, the cooler and therefore reefless coast of New South Wales, although likewise embayed, is island-free and strongly cliffed; and this indicates a long-continued exposure to ocean waves, while its inorganic continental shelf was forming off-shore. All along the east Australian coast, the former eastward extension of the mainland has been rather strongly submerged, apparently by down-flexing; in the north it appears to have been prevailingly reef-protected, in the south never reef-protected while the down-flexing was in progress.

Atolls

Atolls resemble barrier reefs in all particulars, except that no islands rise from their lagoon. The largest atolls are from forty to sixty miles in diameter; the smallest are less than a mile across, without a lagoon. Atoll reefs are rarely circular, usually irregular in pattern. Low islands of reef sand are often spread on the flats of barriers and atolls by waves and winds; they commonly become bush- and tree-covered, and are often inhabited; but they are exposed to the occasional danger of being overwhelmed without warning by earthquake waves.

[1] W. S. Kent, "The Great Barrier Reef of Australia," London, 1893.

Intermediate Reef Forms

The three classes of reefs grade into one another. An outstanding fringe, separated from the shore by a narrow belt of shallow water, resembles a close-set barrier. Some fringes gradually depart from the shore and become barriers; thus a fringe along the southeast side of Ngau, in central Fiji, becomes a well-offset barrier on the northwest side of that island. The central islands in certain barriers are so small, although still of mountain-top form, that the reefs may be called almost-atolls. Truk, a large encircling reef in the western Carolines, and Mangareva or Gambier, southeast of the Paumotus, are among the best examples of this kind.

Elevated and Submerged Reefs

All classes of reefs are found either elevated above or depressed below, as well as at sea-level. Elevated reefs are found abundantly in the East Indies. The large island of Timor bears many such reefs on its flanks, and a number of more or less dissected almost-atolls and atolls surmount its crest at altitudes of about four thousand feet; these are the loftiest reefs known. A fine elevated barrier, still enclosing a shallow lagoon, rises like an even-crested wall to a height of 180 feet along part of the northeast coast of New Georgia in the Solomon Islands. Vatu Vará is an elevated atoll of small diameter in central Fiji, 1,030 feet in altitude. The three Loyalty Islands, Mare, Lifu and Uvea, northeast of New Caledonia, are elevated atolls; the first two are evenly uplifted; the northwestern one, Uvea, is tilted to the northwest, so that its emerged southeastern arc has a somewhat crescentic outline, while its submerged northwestern arc is built up by new reefs. A fine submerged barrier, over two hundred miles in length, lies off the northwest coast of Palawan, the southwestern member of the Philippines. Two long stretches of a "sunken barrier" interrupt the great sea-level barrier reef that fronts the south coast of eastern New Guinea. Chagos Atoll in the central Indian Ocean, ninety-five by seventy-five miles across, is submerged to a small depth around nearly all its great circuit. Nearly a score of submerged atolls lie north of Fiji in the equatorial Pacific; their district may well be called the Darwin Hermatopelago or Sea of Banks. A deeply submerged reef seems to be indicated by a dredging made by the Siboga expedition in the Dutch East Indies; it brought up a haul of somewhat decomposed reef-building corals from a depth of over seven hundred fathoms in the Ceram Sea, thirty miles from the nearest land.

Darwin's Theory of Upgrowing Reefs on Subsiding Foundations

Three contrasted theories of coral reefs may be outlined, Darwin's, Murray's and Guppy's. Darwin[2] recognized that atolls might be occasionally formed as crowns on volcanic crater rims or submarine banks, wherever such foundations are provided at proper depth; but he rejected the idea, previously current, that all atolls are thus formed, not only because many atolls are not of crateriform pattern and are larger than the largest known craters, but also because it is inconceivable that volcanic cones should be abundantly built up from the deep ocean floor nearly to the ocean surface, without any part of the crater rim rising above sea-level. He explained barrier reefs (Fig. 2) by the upgrowth of fringing reefs, begun at small depth on slowly subsiding foundations, the floor of the enclosed lagoon between the reef and the receding shore being evenly aggraded with detritus from all available sources. Under this theory a barrier reef becomes an atoll when the central island of the barrier

[2] Charles Darwin, "The Structure and Distribution of Coral Reefs," London, 1842.

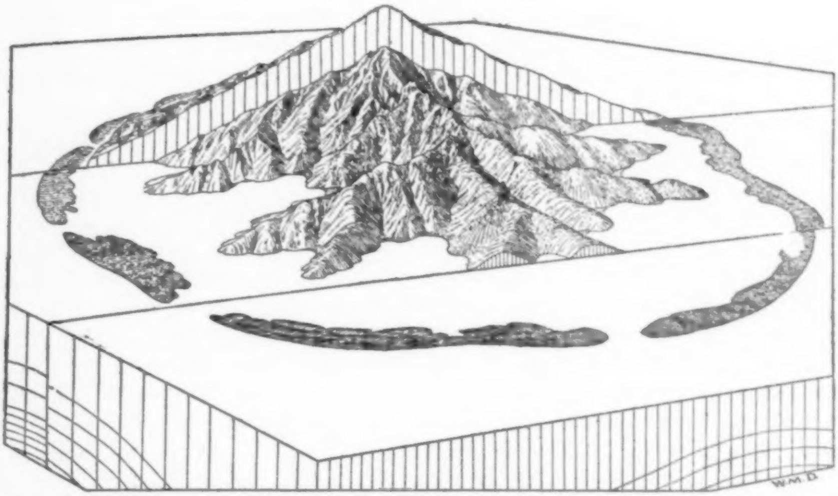


FIG. 2. A THREE-BLOCK DIAGRAM OF A SUBSIDING VOLCANIC ISLAND AND ITS UPGROWING CORAL REEF. BACK BLOCK, A FRINGING REEF ADJOINING THE CLIFFED SHORE OF A MODERATELY DISSECTED ISLAND. MIDDLE BLOCK, A BARRIER REEF ENCIRCLING A MATURELY DISSECTED ISLAND, WELL EMBAYED BY PARTIAL SUBMERGENCE. FRONT BLOCK, PART OF AN ATOLL ENCLOSING AN ISLAND-FREE LAGOON.

subsides below sea-level. Darwin associated fringing reefs as a rule with coasts of emergence, but he noted also that if a fringe or barrier be drowned by rapid subsidence, a new fringe, formed above the drowned reef, will rest upon a coast of submergence. He knew of no examples of such reefs, but they appear to be not uncommon in the East Indies.

MURRAY'S THEORY OF OUTGROWING REEFS ON STILL-STANDING FOUNDATIONS

Murray[3] rejected Darwin's assumed subsidence and explained barrier reefs by the outgrowth of fringing reefs on their own talus from stationary coasts; and he regarded the lagoons as excavated by solution of dead rock behind the advancing reef front, thus repeating an idea of Semper's (1863). Murray also suggested that atolls might be sometimes formed from barrier reefs by the degradation of the central island; but his preferred view as to atolls was that they are crowns upon banks that have been organically aggraded over still-standing submarine foundations, usually volcanic cones, of whatever depth, thus repeating an idea of Rein's (1870, 1881).

GUPPPY'S THEORY OF REEFS FORMED ON RISING FOUNDATIONS

Guppy believed that coral reefs are formed on rising foundations.[4] Atolls would thus crown shoaling but not emerged banks; barrier and fringing reefs would grow on or near emerged slopes. The lagoons of barrier reefs were explained by this observer as covering platforms cut by marine abrasion in coastal slopes during a pause in their emergence, thus repeating in essence an idea of Tyerman and Bennet's (1829), but without giving any reason for the failure of protecting reef growth while

[3] Sir John Murray, "On the Structure and Origin of Coral Reefs and Islands," Proc. Roy. Soc. Edinb., x, 1880, 505–508; also, "Structure, Origin and Distribution of Coral Reefs and Islands," Proc. Roy. Inst., xii, 1887, 251–262.

[4] H. B. Guppy, "The Solomon Islands, their Geology. . . ." London, 1887; also, "The Origin of Coral Reefs, Proc. Vict. Inst., xxiii, 1890, 51–68.

the platform was abrading, or for the cessation of abrasion after a platform of whatever width had been cut.

Points Omitted from Guppy's Theory

The inventors of these several theories adopted them without making a sufficiently thorough deduction of their consequences. Thus Guppy overlooked three significant points: (1) If fringing reefs are formed on rising coasts, they should lie conformably on non-eroded slopes; but most fringing reefs lie unconformably on slopes that had been subaerially eroded before the reefs were formed; thus showing that subsidence had preceded reef growth even if upheaval had later followed subsidence. (2) If barrier reefs rise from platforms cut in rising coasts, the shore back of them should be cliffed and not embayed, as in sectors H, J, K (Fig. 3), but such shores are in nearly all cases embayed and not cliffed, as in sector O. (3) If atolls are based on non-emerged shoals, their limestones should lie conformably on the non-eroded surface of the shoals; but several elevated atolls are known to rest unconformably on subaerially eroded foundations, which must therefore have sunk before the atoll limestones were laid upon them.

Points Omitted from Murray's Theory

Murray overlooked five significant points: (1) If narrow fringing reefs begin to grow outward from stationary coasts, they will in most cases be soon smothered by detritus washed out of the coastal valleys and swept along the shore by the waves, whereupon the reefs will be cut away and the shore attacked and cliffed. This argument serves also to contradict the suggestion that barrier reefs may be built up from whatever depth on the submerged flanks of still-standing islands; for in such case, the incipient fringing reef on the shore being smothered by outwashed detritus, the island would have a cliffed and non-embayed shore by the time the barrier reef was built up to sea-level around it; but the central islands within barrier reefs are seldom cliffed and are always embayed. (2) If fringing reefs should

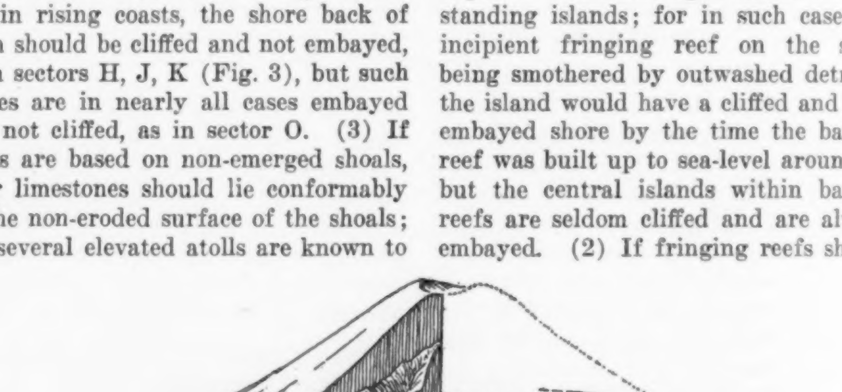


Fig. 3. Sector diagram, illustrating Guppy's theory of reef formation. Sector H, a slightly cliffed island; H', the same with a close-set barrier reef. Sector J, a strongly cliffed island; J', the same with a well offset barrier reef. Sector K, an almost consumed island; K', the same encircled by an almost-atoll reef. Sector O, a maturely dissected, well embayed, non-cliffed island, such as is usually encircled by a barrier reef.

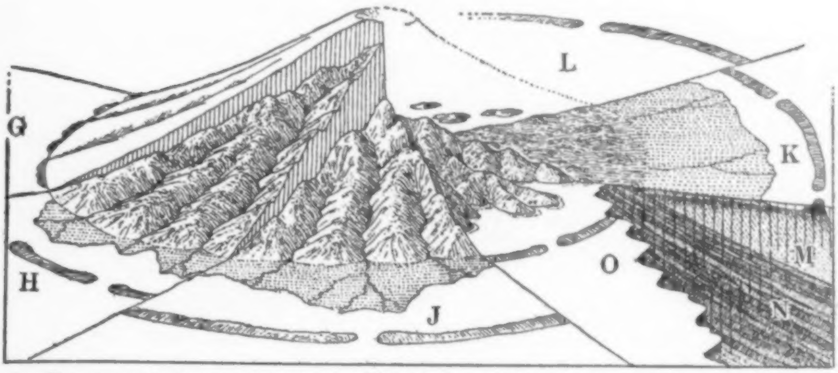


FIG. 4. SECTOR DIAGRAM, ILLUSTRATING MURRAY'S THEORY OF CORAL REEFS. SECTOR G, A FRINGING REEF ATTACHED TO A YOUNG VOLCANIC ISLAND. SECTOR H, A BARRIER REEF FRONTING A WELL DISSECTED ISLAND FRINGED WITH ADVANCING DELTA FLATS. SECTORS J, K, AN INCREASINGLY DEGRADED ISLAND WITH WIDER DELTA FLATS ENCIRCLED BY BARRIER REEFS. SECTOR L, THE LOW ISLETS OF A VANISHING ISLAND ENCIRCLED BY AN ALMOST-ATOLL. THE SUBMARINE SECTION OF SECTOR K SHOWS THE REEF-TALUS, M, RESTING ON THE NON-ERODED SLOPE, N, OF THE VOLCANIC CONE. SECTOR O, THE EMBAYED PATTERN OF ISLANDS USUALLY SEEN WITHIN BARRIER REEFS.

succeed in growing out and forming barriers, the stationary coast behind them will not be embayed, as it is in practically all cases. (3) If lagoons are excavated by the solution of dead-reef limestones, their floors, where not consisting of incompletely removed, bare and ragged rock, should be covered with insoluble residue, instead of being covered with accumulating calcareous detritus, as is commonly the case. (4) If barrier reefs are ever transformed into atolls by the degradation of stationary central islands, then the islets of almost-atolls should be low and flat, as in Fig. 4, sector L; but such islets are always of mountain-top form, as in Fig. 5, sector D. (5) If most atolls are crowns on organically aggraded, submarine banks, then elevated and dissected atolls should show pelagic deposits between a non-eroded volcanic base and the coral crown; but as a matter of fact only two elevated atolls—Roti in the Dutch East Indies and Barbadoes in the Lesser Antilles—are known to be underlaid by pelagic deposits; and in both of these islands the pelagic deposits lie unconformably on subaerially eroded, non-volcanic rocks, thus showing that island subsidence, at a rate too fast to be counterbalanced by reef upgrowth, had preceded a later and slower upheaval with reef growth and emergence.

POINTS OMITTED FROM DARWIN'S THEORY

Darwin failed to recognize three significant elements of his theory: (1) The disappearance of the great volumes of detritus that have been, in most cases, eroded from coasts fronted by barrier reefs, is best accounted for by subsidence. (2) If barrier reefs have grown up from slowly subsiding foundations, the coasts from which they are offset should be embayed by the partial submergence of the coastal valleys, as in Fig. 5, sectors B, C, E. (3) If the formation of barrier reefs and atolls is associated with the subsidence of their foundations, the lagoon limestones—but not necessarily the external talus deposits—should lie unconformably on the subaerially eroded slopes and summits of the foundation rocks.

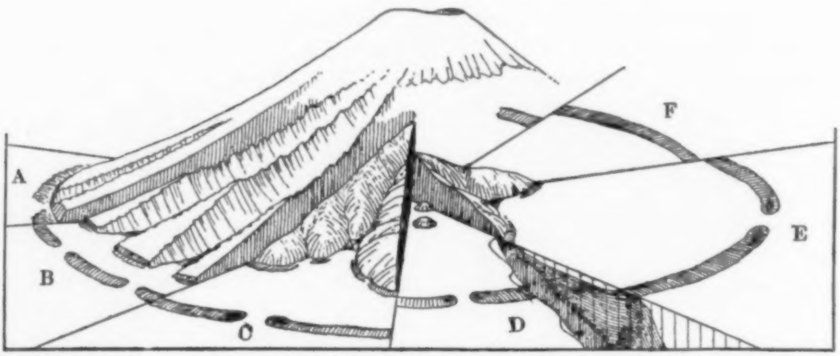


FIG. 5. SECTOR DIAGRAM, ILLUSTRATING DARWIN'S THEORY OF CORAL REEFS. SECTOR A, A FRINGING REEF ATTACHED TO PLUNGING CLIFFS OF SLIGHT SUBMERGENCE. SECTOR B, A BARRIER REEF FRONTING NEARLY SUBMERGED SPUR-END CLIFFS BETWEEN EMBAYED VALLEYS. SECTORS C, E, A MATURELY DISSECTED, REEF-ENCIRCLED ISLAND, SO WELL SUBMERGED THAT ITS EARLY-CUT CLIFFS HAVE VANISHED. SECTOR D, AN ALMOST-ATOLL ENCLOSING A LAGOON WITH RESIDUAL MOUNTAIN-TOP ISLETS.

CONFIRMATION OF DARWIN'S THEORY

But while the unnoticed consequences of Murray's, Guppy's and several other theories are strongly contradicted by the facts of observation, thus condemning those theories, every one of the unnoticed consequences of Darwin's theory is confirmed by the facts. (1) The volume of detritus that has been eroded from reef-fronted coasts would in nearly all cases have filled—often much more than filled—the reef-enclosed lagoons and overwhelmed the reefs, had the coasts remained stationary. (2) The central islands of barrier reefs are embayed, as Darwin knew; but it was Dana who first showed (1849) that such embayments necessarily result from the entrance of arms of the sea into the coastal valleys as subsidence progresses. Tahaa in the Society group (Fig. 1) is a typical example of an embayed island. (3) Elevated reefs nearly always rest unconformably on their foundations, as was first clearly pointed out by Walther in his study of the raised reefs of Sinai Peninsula in the Red Sea (1888). The elevated barrier of Mangaia in the Cook group of the Pacific has recently been shown by Marshall (1927) to rest unconformably on a well-eroded volcanic foundation, which must therefore have slowly subsided while the reef grew up around it. In the elevated atoll of Tuvuthá in eastern Fiji an unconformable contact of the reef limestones on a subaerially eroded volcanic cone has been reported by Foye (1918), who also found in the near-by Exploring Isles a similar relation between the limestones of several elevated reefs and their volcanic foundations. The association of subsidence with reef upgrowth in such cases seems unquestionable. Moreover, as these elevated reefs have been impartially selected for elevation, by deep-seated telluric forces of upheaval, they may be fairly taken as types of many barrier and atoll reefs which still lie at sea-level. Finally, if a theory involve various consequences not noticed by its inventor and if these consequences are confirmed by later-discovered facts, the theory is thereby strongly supported; and such is emphatically the case with Darwin's theory.

DALY'S GLACIAL-CONTROL THEORY

The novel glacial-control theory recently put forth by Daly[5] is based on

[5] R. A. Daly, "Pleistocene Glaciation and the Coral Reef Problem." Amer. Jour. Sci., xxx, 1910, 297–308; also, "The Glacial-Control Theory of Coral Reefs," Proc. Amer. Acad., li, 1915, 155–251.

the similar depth of reef-enclosed lagoons, which he believes can not be explained by the subsidence theory. He assumes that, as a rule, reef foundations have long been stationary; that many of the older volcanic islands of the Pacific had been degraded in Preglacial times to low relief with deep-weathered soils; that no barrier or atoll reefs but only fringing reefs were formed in Preglacial times; that with the coming of the Glacial period the ocean was lowered some thirty or forty fathoms by the withdrawal of water to form continental glaciers and ice-sheets; that even in the torrid zone the reef-building organisms were weakened or killed by the chill of the lowered ocean so that the ocean waves, first cutting away the dead reefs, then abraded the worn-down islands to low-level platforms; and that, as the ocean rose and warmed again in Postglacial time, barrier and atoll reefs grew up on the platform margins, enclosing lagoons at first everywhere of nearly uniform depth, although the smaller lagoons have later been much shoaled.

Invalidation of the Glacial-control Theory

This ingenious theory is largely invalidated by the various evidences of island instability above presented; also by the prevailing absence of cliffed shores back of close-set barrier reefs; for if many old, previously worn-down islands were completely abraded in the Glacial period, a fair number of less old islands should have been less worn down in Preglacial time and incompletely abraded in Glacial time, and such islands should to-day show partly submerged cliffs—plunging cliffs—back of barrier reefs; but islands thus cliffed are almost unknown in the coral seas. Yet as plunging cliffs do characterize a good number of islands that surmount imperfectly reefed banks in the marginal belts of the Pacific and Atlantic coral seas, it seems probable that Daly's factor of low-level abrasion —but not his postulate of island stability—there finds application. In this and a few other respects, Darwin's original theory, now ninety years old, may be, as I have elsewhere shown in detail,[6] modified to advantage, as follows.

Reefless Continental Coasts

Continental coasts of emergence are, as a rule, unfavorable to reef growth, because they consist of unconsolidated sediments; witness the Madras coast of India. Indeed, nearly all the torrid coast of the Indian Ocean west of the head of the Bay of Bengal is as reefless as the Madras coast: the near-shore reefs along a stretch of the east-equatorial coast of Africa have probably found their opportunity in association with a small submergence which has there interrupted the elevation that generally prevails elsewhere. Continental coasts of submergence are also unfavorable, if they are mountainous and rainy, as is for the most part the case with the coast of Asia from the head of the Bay of Bengal southeastward around the Malay peninsula and northeastward nearly to the delta of the Hoang-ho; for all along that embayed coast the outwash of detritus appears to be so abundant as to make the sea-floor muddy: even on outlying islands fringing reefs are rare around this long stretch of embayed continental margin. Many islands in the East Indies bear fringing reefs, as already noted, apparently because during the partial submergence from which many of them are now recovering, their abrupt shores expose much bare rock, instead of being cloaked, like the Madras coast, with loose sediments.

[6] W. M. D., "The Coral Reef Problem." American Geographical Society, New York, 1928. The illustrations of the present article are reproduced from this book.

Reefless Young Volcanic Islands

Young volcanic islands are also, as a rule, unfavorable to reef growth, because of the abundance of down-washed detritus which soon forms a beach around their shores, smothering incipient reefs and permitting abrasion; witness Reunion in the Indian Ocean and a number of reefless young volcanic islands in the East Indies. But embryonic fringing reefs may be locally and temporarily formed on the lava-flow salients of young volcanic islands, elsewhere beached and cliffed; witness Ambrym in the New Hebrides.

Reefs on Subsiding Volcanic Islands

Not until a young volcanic island has been more or less dissected and until its subsidence has disposed of the detritus eroded from it—the spontaneous or isostatic subsidence of a volcanic island being likely by reason of its great weight, as Molengraaff has suggested (1916)—will the submergence of its cliff-base beach permit reef growth to begin, either on the plunging-cliff faces or somewhat off-shore on the cliff-base platform. The Marquesas Islands seem to offer examples of incipient plunging-cliff reefs thus conditioned. Subsidence, therefore, appears to be essential not alone in disposing of outwashed detritus, but also in introducing the special conditions which permit the first successful establishment of young reefs and their further growth. In this respect Darwin would seem to have builded better than he knew. Yet if a long still-stand pause ensue after early subsidence and incipient reef growth, a new beach may in time be built up, whereupon the young reef will be smothered and abrasion will be resumed. Hence, not unless slow subsidence continues and maintains embayments in the coastal valley mouths, where down-washed detritus will be deposited in bay-head deltas, are up-growing reefs likely to persist. Even then, they may be after a time drowned by rapid submergence, as appears to be the case with a young barrier reef now submerged around the much-dissected and well-embayed island of Tutuila, Samoa.

The Plunging Cliffs and Barrier Reef of Tahiti

On the other hand, if subsidence continues at a moderate rate, the on-shore or near-shore reef may grow up as an off-shore barrier, enclosing a lagoon before the previously abraded cliffs are wholly submerged; and such seems to be the case of Tahiti in the Society Islands, where the many radial spurs between the deep-cut and partly submerged radial valleys are cut off in cliffs that appear to plunge below present sea-level. Yet here a somewhat prolonged still-stand pause, since the partial submergence of the spur-end cliffs and the accompanying embayment of the valleys permitted the upgrowth of the barrier reef, has caused the filling of nearly all the valley embayments with deltas, which have become laterally confluent and advanced somewhat into the lagoon, narrowing it and smothering many cliff-face fringing reefs. Indeed, even the off-shore barrier reef appears now to be somewhat endangered by the outflowing floods of muddy fresh water from the advancing delta flats. Further subsidence would drown the flats, widen the lagoon, reembay the valleys, and rescue the barrier from the danger which now threatens it. Continued subsidence would in time completely submerge the spur-end cliffs, and the inter-bay spurs of the diminishing island would then slope gradually down into the widened, reef-enclosed lagoon. This stage appears to be already reached in the other members of the Society group farther to the northwest; for as one proceeds in that direction, the islands are found to be more and more dissected, and of smaller and smaller size, as if of earlier and earlier

origin and increasingly submerged; and still farther northwest the barrier-reef islands are followed by atolls, the island foundations of which have completely disappeared. Be it noted here that the cliffs of Tahiti should not be ascribed to low-level abrasion during the Glacial period, for in that case all the other islands of the group should also be cliffed, and they are not.

The Varied Reefs of Fiji

The Fiji Islands contain a greater variety of coral reefs than is to be found in any other group in the open Pacific. Indeed, in eastern Fiji, the association of fringes, barriers and atolls, both at sea-level and elevated, is so close that Darwin's theory has been held inapplicable there, even by so eminent a former supporter of that theory as Sir Archibald Geikie. But when the reefs of eastern Fiji are examined deliberately, it appears that Darwin's theory is really the only one that can reasonably account for them. It does so admirably on the not unreasonable assumption that the various changes of level which the eastern islands have suffered are due to the slow westward migration of a broad and low anticline with a preceding and a following syncline in the ocean floor.[7]

Coral Reefs in the East Indies

In the East Indies in general, recent movements of elevation and depression have been so active that typical sea-level barrier and atoll reefs are not often found there; but elevated reefs of various kinds abound. The moderate thickness of many elevated fringing reefs on the slopes of these islands has been illogically taken to argue against the correctness of Darwin's theory, which necessitates a great thickness for many barriers and a still greater thickness for many atolls in the open Pacific. But the proper interpretation of these thin fringing reefs, all of which rest unconformably on their island slopes, is that they represent relatively short-lived pauses in movements of upheaval or subsidence, which were at other times too

[7] W. M. D., "A Westward Migrating Anticline in Fiji." Amer. Journ. Sci., 1927.

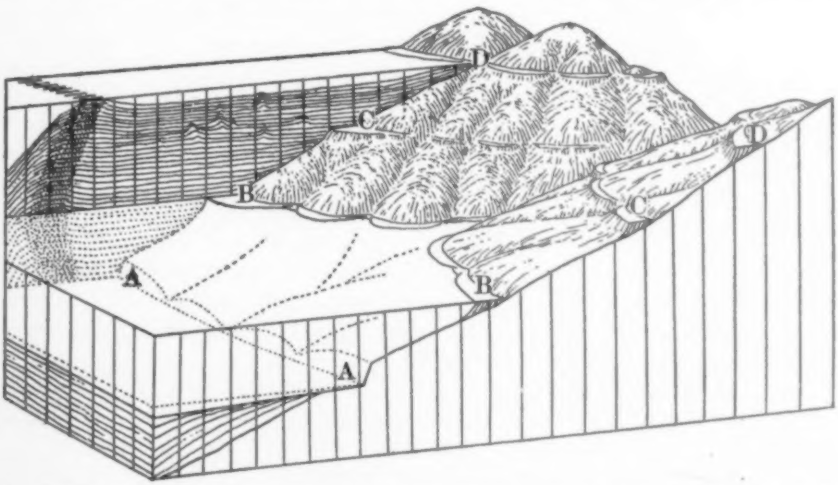


Fig. 6. Block diagram, illustrating the production of thin fringing reefs, B, C, D, in consequence of rapid changes of level in a subsiding and rising coast: in background, a heavy barrier reef and its thick lagoon limestones, formed by upgrowth on a slowly subsiding coast.

rapid to permit reef growth, as in the foreground of Fig. 6. Had the changes of level, especially the subsidences, which are there recorded taken place slowly, a fair number of barrier or atoll reefs one or two thousand feet thick would have been formed, as in the background block of Fig. 6.

The Atolls of the Open Pacific

The various groups of atolls in the open Pacific are to-day the most uncertain elements of the coral reef problem. They can be explained only by the aid of analogy with elevated barrier and atoll reefs elsewhere, as stated above: except that on Funafuti in the Ellice group a boring, made under the auspices of the Royal Society of London, to a depth of 1,184 feet—a small measure compared to the presumable thickness of the reef—has shown that shallow water organisms occur down to that depth in the reefrock, while deeper-water organisms occur at similar depths on the outer slopes of the reef; and this manifestly supports Darwin's theory. A number of reefs in Florida have been shown by Vaughan to have been formed at times of subsidence, but these are of small thickness and have little resemblance to the barrier and atoll reefs of the mid-Pacific.

Conclusion

In conclusion it may be said, in view of what is at present known of the coral reef problem, that in spite of the abandonment of Darwin's theory by many students of the subject in the past fifty years and notwithstanding the various obituaries that have recently been written over the supposed demise of that old theory, it is destined, when subordinately modified as above outlined, to regain in the next fifty years the general acceptance that it enjoyed through the middle of the last century.

COOPERATIVE FISHERY INVESTIGATIONS IN LAKE ERIE[1]

By ELMER HIGGINS

U. S. BUREAU OF FISHERIES

AT the conference of biologists called by the U. S. Commissioner of Fisheries on February 6, 1928, at Cleveland, Ohio, the survey of research problems contributed by the individual participating investigators showed a remarkable unanimity of purpose. The central theme of each program of investigation submitted, the activating principle behind every project concerned the solution of the problem of conservation of Lake Erie's fisheries. It may be desirable, therefore, to review the principles and examine the field of study so that maximum progress can be made on the more urgent problems through the coordination of activities.

It is well established that certain of the fisheries of Lake Erie have suffered a material decline in productivity during the past two decades.[2] The more valuable food species have suffered most and the total yield of the commercial fisheries has only been maintained through a tremendous extension of fishing gear and effort and through the substitution in the market catch of less valuable or desirable species for the more popular varieties. But the decline in abundance of any species or of the fisheries as a whole has not been constant. The commercial yields, reflecting in a general way only the actual abundance of the fish themselves, has varied materially from year to year. The figures of the total commercial catch, however, can not be accepted as an index of abundance due to the interfering influence of environmental and economic forces. Changes in real abundance, involving both long-time and seasonal or short-time fluctuations, can not be determined at once from the data already existent, but variations in both abundance and composition of the fish stock must be determined by exact quantitative studies in order to discover the real trend and condition of the fishery.

As in the great marine fisheries, fluctuations in abundance of fish in Lake Erie are conditioned upon and explained by fluctuations in the age composition of the individual species, and these fluctuations in turn are due to the effects of diverse circumstances, such as, for example, changes in the environment by pollution of waters and increased mortality from commercial fishing. From a biological point of view the problems of the fisheries of Lake Erie are bound up in those fundamentals of growth and survival of each species, such as birth-rate, death-rate and migration or behavior.

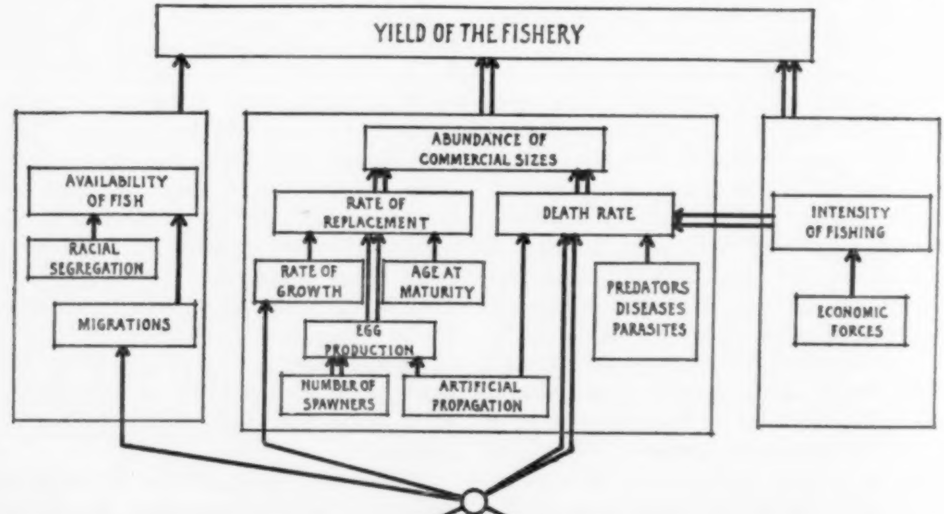
While the value of the fisheries of Lake Erie to the sportsman, the angler and the vacationist can not be disregarded and no attempt is made to minimize this value, the primary interest in the fisheries of Lake Erie is economic. Their chief value to the public at large is as a source of food and to the fishing industry—producers and distributors—as a source of profit. It is clear, therefore, that maintaining and increasing

[1] Published by permission of U. S. Commissioner of Fisheries.

[2] Statistics of the yield of the fisheries may be found in the various reports of the U. S. Commissioner of Fisheries and particularly in Document 1001, "Fishery Industry of the Great Lakes," by Walter Koelz. Appendix XI, Report for 1925, and Document 1025, "Fishery Industries of the United States, by O. E. Sette, Appendix V, Report for 1927.

the yield of the fishery is the fundamental and ultimate aim of any system of conservation and must form the central theme of any plan of investigation contemplating the application of results to human benefit. From a practical standpoint the most important question is, "How can we regulate the fishery or change conditions so that fewer adult fish are taken, fewer immature fish are destroyed and opportunities for the fish to reproduce are increased without seriously crippling the fishing industry?" Hence it will be proper to consider the various factors affecting the yield of the fishery and which are therefore worthy of investigation to discover their relationships and the relative importance of their effects.

The following diagram (Fig. 1) is offered as an attempt to define the relationships of the major fields of investigation, together with many of the minor factors influencing the yield of the fishery. An attempt has been made to present in graphic form a simplification rather than an elaboration of the elements of fishery science. Such a diagram can be extended indefinitely by the addition of details and no doubt may be simplified by reclassification and combination. Furthermore, no attempt has been made or could be made successfully in the present stage of development of the science to indicate the coordinate or subordinate importance of the many factors influencing abundance. It still remains to be determined by future investigations in each particular fishery which force or combination of forces exerts the dominating influence upon the yield. In the diagram the connecting arrows indicating the direction and relation of the interacting forces have



A GRAPHIC REPRESENTATION OF THE FIELD OF FISHERY INVESTIGATION SHOWING THE INTERRELATIONS OF VARIOUS FACTORS AFFECTING THE YIELD OF THE FISHERY.

been doubled in those cases which are believed to be most important, but even this is subject to complete revision with the accumulation of experience. In not all cases does the logical arrangement of factors indicate the proper sequence of investigation. It is hoped, however, that the diagram will be suggestive of both logical and practical relationships of the various problems and may indeed suggest short cuts to their final solution.

The yield of the fishery is directly dependent upon three major factors: First, the abundance of the commercial sizes; second, the availability of the fish to the fisherman; and third, the intensity of fishing effort. As biologists, we are concerned primarily with the abundance of the fish themselves, since such factors as growth rate, death rate, spawning and development, food supply, competitors, diseases, etc., together with the effects of physical features of environment fall within the conventional limits of biology. But as investigators in a field that may be characterized as *fishery science*, the other two factors affecting the yield of the fisheries, *viz.*, the availability of the fish and the intensity of fishing effort, must receive their share of careful consideration.

From a purely theoretical standpoint the factors of abundance and intensity of fishing are variables of the first order of importance in their effects on the yield of the fishery and in some fisheries, such as those for halibut or cod or salmon, they may include the entire range of effective influences. But from a practical standpoint in the case of the Great Lakes fisheries and the pelagic marine fisheries the varying accessibility of the schools of fish contributing to the commercial yield constitutes a factor of considerable significance. Although availability may be considered a phase of abundance, it is entirely distinct from abundance in that it is not directly affected by the intensity of fishing nor by rates of replacement or mortality. In this way racial segregation and migration, both seasonal and diurnal, have a real effect upon the commercial take without that theoretical bearing on abundance which is recognized by many as an important factor in the growth of populations. Since availability has a primary and direct effect upon the yield and is conditioned upon complex and obscure factors of the biological and physical environment causing migrations, it becomes a proper subject of inquiry by the fisheries investigator.

The third factor of first-order significance that affects the yield of the fishery is that of the intensity of fishing effort. It is obvious that the fish may be abundant and within reach of the fishermen's nets, but if the number of fishermen and the number and size of the nets employed is small the yield can not be great, and experience has taught us that a continued decline in real abundance can be entirely masked in the figures of the yield by an increased intensity of fishing. The yield of the fishery, therefore, varies directly with changes in the intensity of fishing.

The effects of commercial fishing upon the fish stock are extremely complex. In addition to its obvious direct relation to the yield it increases the death-rate and reduces the abundance of commercial sizes. Indeed, commercial fishing may be so extensive in certain fisheries, as proved by abundant evidence from the North Sea, the North Pacific and elsewhere, as to constitute the primary factor in increasing the death-rate. Furthermore, it affects the rate of replacement and egg production through direct attack upon the adult population composed of spawners. It produces material changes in the relative proportions of the different age classes in the population, in the density of population and possibly in the rate of growth and the age at maturity. These last-mentioned results, however, tend to pro-

duce a compensating effect in the rate of replacement. Indeed, the occurrence of the increased resistance to the strain of fishing at lower levels of abundance as shown in the halibut and plaice fisheries is explained by this acceleration in the rate of replacement resulting from decreased density of population and related increase of food supply. This increased resistance is probably a vital factor in the maintenance of the intensive fisheries of Lake Erie.

It is in investigations of the intensity of fishing that the biologist finds himself on the least familiar ground, for the factors that control intensity are almost entirely economic. Fortunately, the evaluation of the intensity of fishing is all that is necessary in understanding the effects of this factor on abundance of fish, but it is in the devising of fishery regulations that the economic questions must be most carefully considered and in this the fishery biologist must invite the collaboration of the business expert and the political economist.

Concerning the practical bearing on fish production in Lake Erie of other biological factors and of the chemico-physical factors of environment shown in Fig. 1, little can be said at present. It should be recognized that these influences are logically subordinate in importance to the three prime factors of abundance, availability and intensity of fishing, but until they have been specifically investigated with special reference to each important commercial species of fish, the practical significance of the various factors can scarcely be estimated. This does not minimize the desirability of conducting serious investigations of these subjects. They represent ultimate rather than immediate causes of variations in the fishery and as such may hold the key to the final solution of the problem of fishery conservation. As a basis of fishery regulations these more remote factors have added significance if it is assumed that the decline in the fishery is largely the result of changed physical environment, but they shrink in importance if the decline is due to over-exploitation of the fish stock. Since neither of these assumptions has been proved in the Great Lakes and since pollution and overfishing are both gravely suspected there is every reason for conducting inquiries into these causes of changing supply.

An investigation of the fisheries of Lake Erie may be divided into three branches or subdivisions which overlap but are essentially distinct in method, viewpoint, prerequisite training and personnel. The first is an examination of the yield of the fishery and an evaluation of the intensity of fishing for the purpose of determining the relative abundance of the fish stock of each species. Continued year after year this investigation will yield a true concept of the trend and condition of the fishery and provide many facts bearing on the biology of the fish that are useful in explaining the observed variations in abundance. The second includes a biological study of the fish, their life history, migrations, racial segregation, food, etc., which is essential to the proper interpretation of the study of abundance. The third branch is chiefly limnology, a study of the chemical, physical and biological features of the environment and the ecology of the larval fishes while they are a part of the plankton.

The practical operations in each of these three fields of investigation and the cooperating investigators of the various organizations interested in the biology of Lake Erie fishes may be listed as follows:

(1) The yield of the fishery and the intensity of fishing effort is being determined in New York state waters by the Bureau of Inland Fisheries of the State Conservation Commission, which has instituted a system of fishery statis-

tical returns furnishing sufficient information to yield an index of abundance of direct use to the fishery biologists. This system is similar to the one adopted by Michigan in September, 1927. It is understood that the states of Ohio and Pennsylvania, although no action has yet been taken, will institute similar systems and it is hoped that like action will be taken by the province of Ontario. As these records of yield and intensity in the various states accumulate through the years it is intended that the Bureau of Fisheries shall act as the central agency in assembling and analyzing them to determine the trend of abundance for the important species of the entire lake.

Of direct bearing on this study of abundance is the present work of the Bureau of Fisheries in defining and stabilizing the unit of fishing effort. To this end the effects upon the fish stock of the various types of commercial fishing gear, their efficiency and their destructiveness, is being investigated and recommendations for the most satisfactory types of gear will be issued to the various states.

(2) The life histories of the important species of fish are being investigated by the staff of the Bureau of Fisheries. The herrings, whitefish and pike perches are being studied first and other species will be investigated as personnel and facilities become available. The age and rate of growth, age at maturity, egg production, spawning and development and the age composition of the commercial catch together with the periods of greatest mortality in adult life are being fully investigated. The states of New York and Ohio and the province of Ontario are cooperating with the bureau in a study of migrations of adult fish by means of extensive tagging experiments at both ends of the lake.

The food of the important commercial species, together with their enemies, diseases and parasites, is being investigated by workers in Ohio and New York. Improvements of artificial propagation in increasing egg production and in reducing the death-rate in fry are receiving attention at the hands of the Ohio Division of Fish and Game through studies on hatchery technique in collecting and impregnating the eggs and in rearing and planting the fry.

(3) In the field of limnology and ecology, the states of Ohio and New York are assuming leadership. With the Bureau of Fisheries steamer, *Shearwater*, the Buffalo Museum of Natural Sciences is conducting an intensive study of the early life histories of fishes in the eastern end of the lake, together with the plankton communities in which they are found and upon which they depend. The chemistry and physics of the lake waters, the character of the bottom and the distribution of plant and animal life with specific reference to pollution and the obstruction of spawning grounds is also being given careful attention. A parallel line of investigations is being conducted by the Ohio Division of Fish and Game in the western end of Lake Erie. The New York Conservation Commission is conducting an intensive biological survey of the Lake Erie and Niagara River watersheds in which the biological contributions to Lake Erie will be fully investigated, together with the shore life, both plant and animal, within state waters. Certain aspects of fish food production on the bottom of the lake, together with detailed studies of the ecology of bottom organisms, will be conducted by investigators from the Western Reserve University, at Cleveland, Ohio, and the University of Michigan will aid in matters pertaining to technical ichthyology.

From the foregoing account it may be seen that the field of investigation is very broad indeed. Obviously there are many omissions and gaps in the plan

which must be filled in order to make a well-rounded program of research. This is but natural, since the various units initiated individual projects independently at various times and have only considered cooperative efforts at the single meeting at Cleveland. Closer coordination must, therefore, be effected through the conscious effort of the individual investigators to adopt comparable methods in attaining a common goal. As in all new investigations the greatest immediate needs are additional investigators and more funds, but it is confidently anticipated that from the enthusiasm of the workers now engaged the program will gain such momentum that other biologists in the Great Lakes region will join their efforts with the rest and that public appreciation of the nation-wide importance of scientific and practical results will assure adequate financial support from both state and federal governments.

ON RIGHTHANDEDNESS

By Dr. N. WILLIAM INGALLS
WESTERN RESERVE UNIVERSITY

"For he hath done marvelous things: his right hand, . . . hath gotten him the victory."

Few questions of common biological interest can boast of so many and varied explanations as the age-old riddle of right- and left-handedness. Almost every conceivable influence has been invoked, at one time or another, and many of the alleged causes are so grotesque and irrational that one wonders if the authors were really serious in their attempts to find some adequate explanation. With the exception of a certain amount of evidence bearing on the inheritance of handedness, it can not be said that we know much more about the factors which really determine whether an individual will be right-handed or left-handed than did the person in whose mind the question first arose.

The question of handedness is essentially one which has to do with bodily asymmetry, with a certain more or less conspicuous functional inequality of the two sides, most manifest in the hands and arms. It is, therefore, not surprising that the search for etiological factors should have been directed almost exclusively toward other, often equally obvious, asymmetries or differences of the two sides of the body, in the hope that the question of right- and left-handedness would thereby be resolved or at least brought one step nearer solution. The most that can be said for these attempts, many of which have been very painstaking and exhaustive, is that they have brought to light an almost endless array of minor, not to say insignificant, asymmetries of all kinds in all parts of the body. A certain amount of interest may attach to this mass of information; certainly no one can doubt that the two halves of the body, right and left, are not, and need not be, alike or equal. Much has been learned which might have some bearing on the question at issue, while many findings are simply the results of, or are associated with, handedness, but in no sense can they be looked upon as causes. But still at the conclusion of the whole matter we are yet in the dark as to the reason why one person is right-handed and another is left-handed.

Our purpose at present is to call attention to what seems to us some very important aspects of the question; or, if one chooses, to a certain point of view which, as far as we can gather, has not received the attention it deserves. As will become evident later, we shall have nothing whatever to offer by way of explanation as to why one person should be right-handed and another left-handed. This is, of course, the classical question of right- and left-handedness, but in our opinion the nature of the subject is such that it should never have been formulated in this way. There are, in reality, two questions involved; one of these is of very fundamental biological importance and upon this it is possible to offer something concrete and constructive. The other question, on the contrary, is of secondary interest only; it is the classical question just referred to, upon which so much has been written and about which little or nothing is known. For our own part, not only is this latter question of very secondary importance, but we doubt very much if it admits of definite and final solution.

Before presenting our own views on

the subject, it may be well to inquire into the reality of the condition under discussion and also to cite briefly some of the various types of explanation which have been put forward, some of them very old, some comparatively new.

As regards the reality of the condition there is little call for argument. The very antiquity of the question and the variegated mass of literature which has grown up around it offer sufficient evidence that we are dealing with something real, with something, moreover, which demands an adequate explanation. More eloquent testimony, however, than mere lapse of time, more convincing evidence, indeed, than can be found in many a learned page, is scattered everywhere about us, meeting us at every turn. Language and convention, ancient or modern, sacred or profane, offer abundant proof that right is not left and that left is not right. From the solemn heights of a venerable ritual to the commonplaces of everyday life, our whole intellectual and moral fabric bears constant witness to the fact that we are the descendants of a race in which there was a heavy predominance of right-handedness. For this reason only are we "righteous," if such be the case, still lisping the language of a long forgotten past, when "right" was more concrete and tangible and when the distinction between the right hand and the left was still fresh and vivid in the fertile brain of our simple ancestors. If we interpret aright the wealth of linguistic evidence, if we may trust the hoary accumulations of tradition and all the myriad forms of habit and convention, we shall be prepared to admit that in that far-off day right and left possessed a meaning, a reality and a depth of significance utterly unknown to us. They must have stood forth in brilliant contrast, this superiority of one hand and the inferiority of the other; a contrast which could only be heightened, or hallowed, by the sheer weight of its antiquity and the utter ignorance of its real nature.

Primitive man lived and moved in a world of stern and intense reality; a child of nature, there was constantly unfolded before his wondering eyes a never-ending picture, colorful and concrete in the extreme; a picture, of which, in many ways, we possess now only a drab and faded counterpart. Not only did he find that one hand was a better and more obedient servant than the other, but in divers ways he was gradually acquiring points of view and developing certain mental and linguistic habits which were destined later to exercise an almost boundless influence. We reap to-day the fruit and flower, we gather in a harvest as varied as it is bountiful, but the seeds were sown long, long ago. Surely the better side of the body was a most fitting symbol of better things, of better conduct, and the better hand, the more trustworthy servant of the mind, finds its natural apotheosis in all the better things of life. Right was, and still is, essentially, a comparative rather than a superlative term, the better of any two things. So did the aged Israel, much to Joseph's displeasure, cross his hands in blessing, "guiding his hands wittingly" as the record has it, placing his right hand upon the head of Ephraim, who was the younger; his left hand upon the head of Manasseh, the firstborn — " . . . and he set Ephraim before Manasseh."

Few conventions of language, indeed of the human mind in general, can look back upon such a long, yet definite lineage, as the contrasting usage of right and left, in all its protean forms. There is a direct and uninterrupted line of descent down to the present, a line which began with the first dawning recognition of some real difference between the two hands and arms. Then and there right and left were born, where before there had been simply two sides, the one and the other, this side and that side; twin

prototypes they were, of good and evil, of better and worse, of right and wrong. With them, however, there crept into human affairs influences and reactions which cut deeply and sharply into the receptive mind of early man; elements, they were so charged with potentialities that they have colored all subsequent human history.

But this is by no means an isolated case of the development, out of little things, of deep and far-reaching ideas and persistent habits of thought. Other factors were also at work during this seedtime, and the foundations were being laid, widely, if not deeply, for much that was to follow. It were poor grace, indeed, to complain of the soil from which has sprung so much of beauty, so much of truth. If in that dim and distant past our groping forebears builded too often upon the sands, if much of what they reared thereon is threatened like mist before the rising sun, let us endeavor rather to understand than to criticize them and let us also be reminded that those same foundations have carried a priceless heritage for mankind.

Our ancient ancestor was impressed, and very deeply impressed, by other things than the difference between his two hands and arms. The very light which helped him to use those two wonderful instruments, the ever-welcome sun which lighted and warmed the dark, cold recesses where he disputed tenancy with the cave bear and the grim wolf, left an indelible impress upon his whole mental make-up. Light and warmth, and the common source of both transmuted and transfigured his thinking as he in turn transformed the wolf into his most faithful companion. The air he breathed, the water, without which he could not live, and even the blood he spilled in many a mortal combat, all burned themselves so deeply into his innermost consciousness that all the intervening centuries have scarcely dimmed the record.

The other side of the picture is much more lightly drawn, and the opposite characters appear almost solely by contrast. The cold and darkness, the thirst and want, were real enough, but soon forgotten. Comparatively little attention was paid these rather negative things. With but one good arm, the other was left; a sort of poor relation, as it were, distinguished merely by never being right, always antonymic or derogatory. And so, perhaps, long, long after, it might have been some ironic justice of sinister fate which decreed that the left-handed Ehud should lose his sword in the ponderous form of Eglon.

After this digression, which may serve as a part of the background, we may note in passing a few of the explanations which have been offered in regard to right- and left-handedness.

It is not necessary to go farther back than Plato, who supposed that the condition of right-handedness was due to the child being carried on the mother's left arm, but a little thought will convince one that the argument may be used either for or against this view. Quite as old, perhaps, and always popular was the idea of the protection of the heart by a shield on the left arm. In both cases, however, we are obviously dealing with effects and not with causes. Some writers have cut the Gordian knot and supposed that it was a question of training and early education or even a childish obstinacy and opposition to instruction. Although it is doubtless true that there are varying degrees of handedness and that much can be accomplished by training and use, there is, nevertheless, every reason to believe that the condition of handedness was established in a very remote past and that it has come to be such an ingrained characteristic of man that no opportu-

nity is now afforded to reopen the question, beyond the small choice of either right or left. The underlying causes of handedness are to be looked for in the past, not in the present. Heredity, regardless of the rôle it may now play, is silent and helpless as an explanation.

Since handedness appears as an asymmetry of the body, it was natural to look for other asymmetries which might explain it. The heart is on the left side; the center of gravity of the body is a little to the right of the midline; the two halves of the brain are not alike, or do not receive the same amount of blood; the hands and arms may be quite dissimilar, and so on down through the long list of variations between the two sides of the body. Indeed, the very number and variety of the solutions offered would indicate that there is little unanimity of opinion as to the real nature of handedness.

A comparatively late and loud claimant for the honors in this field is the doctrine of ocular dominance. Its chief supports are represented by two quite untenable assumptions. One is that there is a fairly constant and material, qualitative difference in the two eyes, as visual, optical instruments, the right eye being usually the better eye. The other idea, reminiscent of medieval biology in its naïveté, is that each eye controls the corresponding side of the body. The reasoning is simple and sound, the right arm is the better because it is under the direct control of the better eye; the premises, however, leave much to be desired. It is a matter of common knowledge that in using one eye alone there may be a decided preference for one rather than the other, but this choice is not proof of better vision nor does it even correspond essentially with the choice of hands as expressed in handedness. Nature did not spend untold centuries in developing an adequate binocular vision and all the intricate nervous mechanism which goes with it, and then, when the task was done, close one eye and use the other; or even allow the body to be guided and influenced by one eye more than by the other. Without doubt vision has exercised a most decisive influence in the development of the human faculties, but nature has played no favorites with the eyes, they have always been and still are, to all intents and purposes, equal; and, then as now, two eyes were better than one.

We need not be unduly disturbed if the two sides of the body are not exactly alike. Rarely, if ever, in dealing with animate forms does nature achieve a perfect, complete geometrical symmetry. She is, of course, much more interested in function, and slight or even more marked deviations from formal perfection may be of little or no consequence. In the bilaterally symmetrical animals, of which man is a representative, we should not expect a degree of likeness or similarity between the two sides beyond that necessary to guarantee proper and harmonious function. Absolute, mathematical symmetry is not called for.

Notwithstanding all this, however, we have to remember that *asymmetry* has often been a most important method of attaining invaluable functional qualities. Times without number, and in the most unexpected places, asymmetry confronts us as one of the cardinal points in *specialization.*

It is with handedness as a *specialization* and a sign of progress and higher organization, moreover as a distinctly human and relatively late specialization, which we have to reckon. It is to this view of handedness that we would direct attention.

Handedness, either right or left, is something quite different from the numerous other bodily asymmetries, with which, however, it is often confused and from which so many fruitless attempts have been made to derive it. It

belongs, on the contrary, in a much higher category, since it connotes a definite and important functional superiority of one upper extremity as contrasted with the other. It is not something passive or purely receptive, something resident in the real or supposed superiority of any percipient organ, but rather something active, integrative and creative. It finds its peculiar office in the *use* made of the contributions of the senses, and in the *services* rendered thereby; for faith without works is dead.

As previously noted there are two aspects of the subject under discussion. One, by far the more important of the two, concerns the problem of handedness *per se*. The other side of the question, not only of little moment but also exceedingly obscure, is why the choice in handedness falls now on one side of the body, now on the other, more commonly on the right. The point at issue is not, primarily, why one person is right-handed and another left-handed, but rather why he is handed at all, why one arm and hand, quite irrespective of which one it may be, is materially and significantly better than the other, why the difference, why the asymmetry; what value or advantage, be they ever so little, could have accrued to the possessor of one good and one better hand as compared with the doubtful merits of a double mediocrity?

But, strange as it may seem, it is the second question which has claimed the undivided attention of practically every writer who has given the subject any consideration. Only rarely does one encounter even a passing allusion to the larger problem, first by Sir George Humphrey and later in the writings of Elliot Smith.

Handedness is to be looked upon as a specialization, it was one of the harbingers of a new epoch in the history of life, announcing the dawn of the psychozoic era. Since, however, we have two hands and arms, specialization automatically and inevitably leads to differences between the two, in other words to asymmetry of one kind or another. Over and over again, nature, in dealing with bilaterally symmetrical organs, has specialized one at the expense of the other, even doing away with one entirely.

Although handedness is a very convenient and expressive term, it would be more accurate and to the point to speak of brainedness, either left or right. The functional superiority of one limb is essentially dependent upon the functional superiority of that part of the brain which controls and guides it. For the right arm and hand this is the left side of the brain, and for the left arm it is the right side.

The question comes back, therefore, to a specialization of one side of the brain, which would, of course, express itself in the opposite side of the body, in this case in the arm and hand. That portion of the brain concerned is, like the limbs, a bilaterally symmetrical organ, and, consequently, specialization involves the choice of one and only one side, and that more or less at the expense of the other.

This specialization of one side of the brain does not apply to either side in its entirety, but it is restricted in its sphere and range of influence to certain of the newer and more highly organized functional areas of the brain. The reason for this is that it is concerned not so much with the reception of stimuli as it is with their elaboration into appropriate reactions. It is not so much that which comes in as that which goes out; not so much any increase in the extent, variety or precision of sensory impressions, but rather a more thorough integration and correlation of the information already at hand and its translation into new motor responses and finally into creative activity. This significant difference in the two sides of the brain, a certain more or less con-

spicuous superiority of one over the other, is an essentially human characteristic, the last great step forward in human development.

Why, however, most people are right-handed, or rather why, long ago, the left side of the brain gained a slight but effective ascendancy over the right in the majority of cases, we do not know. It is easy enough to grasp the significance and value of the principle of handedness, but what is there to decide the choice between right and left? Certainly the outside world, man's immediate environment, could not have put greater demands upon, or favored, one side of the body rather than the other. On the other hand, there is little or nothing apparent in his own make-up at all calculated, as far as we can see, to throw the choice either to one side or to the other. That the choice was made is perfectly obvious; it would seem, indeed, that it could not have been avoided, and we may never know, at this late day, just why the lots fell as they did. It is altogether possible that very minor, in other respects, quite insignificant factors, might have turned the tide one way or the other; it is not even necessary to suppose that these influences were always the same or that they were always acting upon the same kind of a nervous system. They may have been merely the dust of the balance, as it were, but they contributed some small though signal advantage, and that at a time when little things were weighing heavily in the long upward struggle for the final supremacy of mind over matter.

In the great economy of nature, in her making possible and in her furtherance of human progress, with two sides of the body, with two arms and two hands from which to choose the instruments with which man should work out his own salvation, it has been her way that "the one shall be taken and the other left."

This newer, higher specialization of the brain, which goes under the name of handedness, presupposes a long line of antecedent development, an extended period of conservation and preparation before even the necessary seeds could find a suitable soil. It is not necessary to trace in detail this line of development or to attempt to define its relation to geological landmarks. Man is by no means the last arrival on this humble planet, the final, sudden flowering of the tree of life; unnumbered generations have contributed their modest share; little by little, step by step, he slowly and almost imperceptibly takes form out of the depths and darkness of a past whose antiquity we have only lately learned to appreciate.

If we go back far enough, and it will be many millions of years, we may pick up his trail as a little furry form, spending the short span of his precarious existence close to the ground or at times even underneath it. Guided largely in his little life by the lowest and most uninspiring of the senses, smell, he nevertheless embodied within himself a certain plasticity and adaptability of structure and character, and a stability and primitiveness in organization which were of the utmost importance. Attracted by higher things, he forsook the ground and took to the trees, a most momentous change. That leaving of the ground was a last exodus from the hard bondage of the lowest senses and the meaner things in life, for it is utterly impossible to build up a respectable nervous system on smell and taste alone. Subservience to these senses and submergence in what they have to offer forever shuts out the animal from better things, tying him down to an ever-narrowing life or leading him into the fatal cul-de-sac of some protective or adaptive specialization.

Once well in the trees a new world opened before him. Sight, instead of smell, became the dominant and guiding influence in his life. The peculiarities of his new environment were admirably adapted to call forth the best that was

in him; to enlarge and perfect his vision, to enhance his native nimbleness and agility, as well as to sharpen his wits and enlarge and quicken his resourcefulness. And thus there were gradually unfolded through the coming centuries those innate potentialities which his simple organization and freedom from specialization had preserved. It was to vision more than to anything else that he owed his steady upward climb, as it was a figurative vision which was later to lift him higher and higher, giving him a broader and deeper outlook until at last he should be able to see himself in his true relation to all the world around him. Back of the eyes with their ever-increasing efficiency was a brain capable of encompassing the great variety of impressions offered, and, furthermore, capable of responding to them with rapid growth and with a constant increase in the facilities for retaining, reproducing and elaborating the complex information received. The body grew very materially in size and strength; a host of minor modifications made their appearance, while the proportions of the body were altered in conformity with newer postural habits to the immense advantage of both receptive and motor faculties. But the most conspicuous advantage of these later postural habits, or rather, one should say, of the newer attitude of the animal toward his environment, accrued to the brain. The gradual assumption and establishment of the upright position, the liberation of the arms and hands for newer and more varied activities, and the opening up of wider and more alluring fields for the exercise of his native inquisitiveness, provided alike the opportunity and the stimulus for the final stages of his development. But this opportunity and this stimulus would have availed nothing, and the crowning features of mental development would never have been realized, except for the long, preparatory period of brain development which went before. Escaping the withering influences of the lower senses, and preempted early by sight and touch, the brain had already served a long apprenticeship to these higher senses, as it had also grown and expanded under their guidance until it was finally fitted to reap the full benefits of the information and knowledge which those senses alone could provide.

Just when our little ancestor began to be weaned away from a largely arboreal life, we do not know, nor are we at present concerned with the motives which may have prompted him to exchange, at last, the comparative quiet of his leafy home for the dangers and excitement, and also the opportunities, of terrestrial life. His sojourn among the trees had completely transformed him, he had waxed strong and confident, both in body and mind; quick and keen, he returned to his birthplace and to his birthright, admirably equipped to cope with whatever the future might have in store for him.

But most important of all, he brought into this new life an exquisitely adapted mechanism with which to meet and mold his environment, something with which he could literally and figuratively take hold of and grasp the things around him, shaping his own fortunes like clay in the potter's hand. These instruments, which would either make or break for him, were his hands, his most precious possession, for without them the brain and mind would have remained forever silent and sterile. Only through the instrumentality of his hands could he have developed his brain, and only through his hands could his higher faculties have found adequate and necessary expression. The two are inseparable; the brain presupposes the hand, and the mind of man without the hand of man is unthinkable; so hands without the mind are as vain and empty as sounding brass and a tinkling cymbal.

Few, if any parts of the body, have remained so comparatively unchanged through countless centuries as the

hands. Among the earliest footprints which have come down to us, we recognize at once the typical five-toed form; footprints left in the mud or sand at the water's edge, by some slow-moving, uncouth form which left its watery home to warm its cold blood in the summer sun, and thereby staked out the first claims for the domination of the land by higher forms of life. To that primitive five-toed pattern, as if there were something sacred about it, nature has held with the most remarkable tenacity. Never once, in the long, slow climb from those cold, muddy, all but senseless feet to the hand of man, has there been any material deviation from the original type. Never once has there been any sacrificing or compromising of its general usefulness and almost universal adaptability, for the sake of special efficiency in some restricted field.

Man's feet and legs, on the contrary, have undergone considerable alteration, to the end that they might better support and carry about his head and hands and provide a convenient basis for the use of his arms. They only are specialized, not his hands and arms. And so it comes about that, for taxonomic purposes, he is distinguished almost exclusively by his brain and his feet.

The hand, then, in its essential features, is vastly older than the brain which now commands it. For untold ages it had been lying fallow, as it were, like so many other treasures in nature's storehouse, awaiting only the "Open Sesame" of the human mind. But in the fullness of time that hand was to come into its own and become the living symbol of creative power.

Somewhere, somehow, the curtain slowly rises on the most momentous scene in all the long life history of the earth. From out the uncouth throng which crowds the stage, a single, halting form appears, man; the chief, if not the sole actor in all that is to follow. For many weary centuries he had been struggling to learn his first few, simple lines. Long had he eaten the strong meat of elaborate and inspiring sense impressions, visual, tactile and auditory; long had he contemplated, in his little way, the wondrous world around him; but now the time was ripe for better things, the field was white to the harvest, the kingdom of the mind was at hand.

The day had dawned when that new brain should find something for those old hands to do, something they had never done before, for never before had they been under the spell of such a brain.

As to the nature of these mental and manual activities, we can only speculate. The material evidences of these feeble, faltering attempts to mold the outside world to match the inner thought; these first, prophetic fruits in the garden of art, have, like their creator, vanished completely. They were the expression of the newest and highest faculties, giving evidence of themselves primarily and most typically in the use of the hands and arms; in those activities, moreover, whose highest and finest development not only made possible, but even demanded, commensurate development of one side of the brain, its specialization, in other words, to carry out its own behests. Although it may not be possible to reconstruct those early scenes, or to determine, except in the vaguest outlines, the modes of expression of the nascent intellectual powers, it may, however, be possible to say what they were not.

They are not to be sought in any of those exhibitions of brute force or instinctive cunning which varied or enlivened the weariness monotony of some simple life. Still less were they conceived in the strain and stress of some wild excitement, or born in the face of urgent or unforeseen necessity. No brandished war club or protecting shield, no bitter struggles for some coveted prize, none of the demands of a purely animal existence could have furnished the impetus to cerebral special-

ization or have fed and fostered it once it had arisen.

The beginning specialization of one side of the brain, it does not matter which side, revealed itself in the preference of one hand, rather than two, for finer and more studied movements. The secret of this superiority of one side of the brain and the associated condition of handedness on the opposite side, is to be found, we believe, in the instrumentalities at the disposal of the brain for the working out of its purposes, and in the nature of the work done. When, after a long and varied experience, the accumulated products of countless mental processes should at last break through their barriers, seeking new methods of expression, and when, at last, the brain should really find something to do, it was natural and inevitable that the hands should respond to that call.

The beginnings must have been exceedingly simple, but at the same time they were equally difficult. Those first feeble, all but futile, attempts at creative activity must have taxed to the utmost all the resources of that little mind. Erratic, childish efforts, little more; play perhaps, also, rather than work; and in those early formative times, some material advantage might have been represented by an extended childhood and a long period of bodily immaturity unknown in lower forms. Characteristic of these early efforts was the purpose behind them, some preconceived notion of something to be gained, some idea, however vague, of the methods which might be employed to obtain the desired result. They were little things, for their limit was set by the caliber of the brain; their accomplishment called for no display of strength and endurance, but only for a modicum of skill and patience. The very nature of this new employment was doubtless such that in most cases the two hands would be allotted quite different tasks, but varying all the way from equally divided labor for both hands to total inactivity of one. As a rule one hand would be more specifically charged with the guidance and responsibility for the work to be accomplished; while the opposite hand, indispensable, to be sure, but lacking something in assurance and initiative, profiting always, however, by the experience and virtues of its more favored fellow, would aid as best it could, ancillary, though still invaluable.

The character of these first activities and the resultant division of labor which culminated in handedness were dictated by the brain. In its search for expression it would naturally turn to the things about it, little, simple things, which both brain and hand could grasp and hold. But although there were two strong and eager hands, ready and waiting to lay hold of anything, although the flesh was willing, the spirit was weak. It was easy enough to control two or even four limbs, in fact, to look after the entire body, where it was merely a question of the exercise of those older, inherited, animal activities which served a very different purpose; but to reach out into a new world of thought and action was a very different matter. Where, in the one case, the whole intricate mechanism of the body required but very little formal or conscious oversight, fashioned and perfected, as it had been, through millennia of unvarying routine, in the other, the effective use of even one hand alone, for the new and unprecedented procedures devised by the brain, would sorely try the new-found powers of even the best of these early brains.

One hand was enough—and often more than enough. The first simple, half-unconscious problems were solved largely through the predominant use of one hand or arm. Attacked and solved in this manner, we think, not only because the character of the work demanded or permitted unequal and different services from the hands, but rather because the brain could not give equal

and adequate oversight to both hands at once. It was by no means easy to fix the weak and wandering attention on the task in mind. To determine and carry out the necessary movements, even for one hand and in the crudest manner, was equally difficult and fraught with many failures. Only at the cost of ceaseless efforts was it possible to hold down the wavering attention, only by constant practice did the brain acquire control of itself and thereby mastery of the hand.

It was as if nature had come to the parting of the ways. Future advances in organization and efficiency were to be bought, in part, at the price of specialization. A body of fair size and considerable strength had been evolved; in its structure, proportions and equipment it was unique; as a motor mechanism, as a means of developing power in a wide variety of convenient and available forms, as a simple machine, there was little chance for improvement. Further progress could be hoped for only in the utilization of this power for newer and higher purposes. This entailed no material change, either in the source of that power or in its outward manifestations; but it did demand a very definite enhancement of the functional capacity of the brain and further refinements in its methods of operation. It was not so much a question of new movements of the hands and arms or even of new and novel combinations of old movements as it was a question of cerebral activity which could attain to, and be sustained at, a sufficiently high level to form some conception of the material possibilities implied in those intricate movements, and at the same time imbued with sufficient energy and initiative to follow the feeble light of inspiration wherever it might lead.

With a symmetrical brain presiding over a symmetrical body, there arose the choice of attempting to secure further advancement, either by adhering to a time-honored conservatism and respect for essential symmetry, or by resorting to concentration of effort and the placing of the bulk of the burden on one side of the brain and in one hand. In the natural course of events, abundant opportunity would have been afforded to try out the former method, but the latter was destined to supersede it in the greater promise it offered of fruitful and more immediate results. But as brain has always outweighed brawn—for the race was not always to the swift—so in turn parts of that brain were to outweigh others, one side was to lead the other, in the establishment of a newer and a higher order of achievement.

In the use of one hand the nervous impulses necessary for its control undergo their final elaboration in the opposite side of the brain, and from this side also make their final exit. The predominant and preferential use of one hand, the choice of one alone for more refined operations, the successful performance of which requires special care and studied coordination, are but the outward signs of a nervous activity equally refined and highly coordinated, having its seat in the opposite side of the brain. For the time being that particular side of the brain is more intensely active, and, therefore, for the moment, of greater functional importance, since it represents the last important link in the subtle nexus of brain and hand, of thought and action. Regardless of the various channels through which information may be poured into the brain, regardless, also, of the sources or location of those mental processes which are to find their ultimate expression in manual activity, it is evident that, at some stage and in some form, there must emerge on one side of the brain the materials necessary for the formulation of those final orders, the execution of which is to be intrusted to the opposite hand. The raw materials with which the mind must work may be stored in many places, on both sides of

the brain, its subsequent elaboration and preparation for use may likewise involve wide-spread participation by the higher centers; but if the end results are to manifest themselves in special activity of one hand, then one side of the brain must assume an executive rôle, issue the necessary instructions and accept all the responsibility for their proper performance.

The more one hand became the chief and acknowledged agency in the accomplishment of any purpose, profiting in skill and confidence through constant practice and repetition, the more did that side of the brain in which the control of that hand was vested, enlarge its ascendancy over the other side and further refine and perfect its own intricate processes. The slowly rising stream of purposeful endeavor, flowing outward from brain to hand in ever-increasing complexity and abundance, would draw after it, little by little, the scattered sources of its own supply and tend to focus and concentrate on the same side of the brain not only the final stages of volitional expression, but more and more of the preliminary elements and tributary factors. The resultant specialization, or functional superiority, of one side of the brain, the tendency of associated functions to cluster around some common point, is one of the economies of nature and quite in keeping with some of the most fundamental phases of nervous activity. In this particular case, the special use of one hand and arm, or rather the special quality or capacity of their controlling cortical centers, has furnished the adequate stimulus for other and even higher centers to unfold and develop most conspicuously on the same side. The specialization of the brain for adequate motor control would be more efficient and effective the farther it could reach into the sources which fed and determined that control. Borrowing a figure from political phraseology, and stretching it a little, perhaps, one might say that the executive side of the brain had found it of advantage to appropriate some of the legislative, if not also some of the judicial, functions, which, like the executive, were once equally and evenly distributed. The more definite this specialization of the brain became, the more varied and precise would be its manifestations in the activities of the hands, and both would redound in increasing measure to the profit and progress of their possessor.

But it must not be supposed that the less favored hand would suffer from this apparent slighting. The result has been not a good hand and a poor one, but a good hand and a better one. Not only this, but with increasing mental capacity, either hand is placed in a better position to profit directly by the enhanced skill and assurance of the other, the gain is not manual and local so much as it is mental and general. Nevertheless, there was a parting of the ways, a choice was presented; some division of labor for brain and hand was the apparent answer.

It has been repeatedly noted that man's first activities must have concerned themselves with little things. His eyes were sharp and his hands and arms were strong and supple, but his brain was just beginning to grasp the significance of the things which his eyes and hands had seen and felt for ages. Out of the wealth of sense impressions, present or remembered, he could only evolve a single, feeble thread of thought, only with difficulty and after many trials could he preserve its continuity and succeed in guiding it through new and untried paths into appropriate action. Though fed from various sources, his train of thought was single and unique, but frail and tenuous as well; like the vast majority of all those who have followed him, he thought, and could think, of but one thing at a time, his ideas were essentially successive and in some sequence, not contemporary or parallel. Much of that thinking, more-

over, was most inextricably bound up with the nervous mechanism in immediate control of the hand which was to translate that thinking into action. Hand and brain were working together, each serving and aiding the other, in constant and reciprocal control and guidance.

All things considered, the peculiarities and limitations of the mind and the bilateral character of its structural basis, the corresponding bilateral character of the means provided for its expression and the exceedingly intimate relations between brain and hand; each and all favored the development of a unilaterality, as contrasted with an ambilaterality, primarily of the brain but later involving other parts, favored, in a word, that specialization which has long gone under the name of handedness.

In view of what has been said, handedness was not the product of brute strength, nor was it born of mental tumult and excitement; its essential nature would stamp it as the child of quiet contemplation, for peace hath her victories no less than war. We might, perhaps, picture some uncouth, slouching form, seated at the foot of some great tree or crouched in the cool shelter of some rocky den. Perchance, we should have found him far afield, bent on some special mission, or guided in his ramblings more by native curiosity than preconceived intent, at peace with himself and the world. Somehow his hands would find employment. It may have been only a passing childish interest, something held for a moment in the hands, then cast aside, prompted, perhaps, by some haunting recollection of what was or might have been. It may have been mere aimless play, something to pass the time away, but in the doing some stray sparks may have kindled the light of inspiration or some unforeseen result may have struck the astonished workman with the possibilities of his craft and spurred him on to new endeavors.

The exact nature of man's first activities we shall never know, nor does it indeed concern us; important only was the overshadowing activity and importance of one hand. It does not seem necessary to suppose that the first fruits of his hands should serve some useful purpose, either by design or accident; some real or fancied need may never have occurred to him. His first attempts may have yielded little beyond the joy and satisfaction of creation; beauty may be older than utility, the artist may antedate the artisan. He may well have worked alone at first, half-conscious of his own superiority as the chosen vessel unto better things, patiently plying his little trade, while his less gifted brothers looked on in blank amazement or turned again to their fleshpots. He may have used the right hand or the left, we can not say, he may well have tried them both, learning only by experience which was the better hand. But as time went on, as generation followed generation, it became more and more apparent that a definite choice of hands was being made and that henceforth what we now call the right hand was to wield almost undisputed sway. There were always those who preferred the other side, but they stood out only by reason of that contrast, as there were also a few with naught to distinguish one side from the other.

The reasons for the initial, individual selection of one hand rather than the other, as the more suitable instrument, are hidden from us as completely as are the factors which ultimately brought about the dominance of the right hand as a final, racial character. Even from our present *ex cathedra* position, no peculiar virtues or advantages of the right hand or the left brain are at all apparent. Yet these are the riddles propounded by the classical question of right- and left-handedness, interesting, to be sure, but lacking any deeper importance, and the prospects

for their solution appear so dubious that we are quite willing to leave the quest to others.

If the beginnings were feeble, they were none the less prophetic. Countless centuries had faded into the endless past before the stage was even set for man's appearance. If, at last, his advancement became more rapid and more certain, it was still slow and arduous, for in the sweat of his face should he eat bread. Within his shaggy head, behind that flattened brow, there dimly stirred the most portentous forces. But no Pallas ever sprang from such a head; the ascent of Parnassus was yet a long way off. Time, and a goodly measure of it, was necessary to consolidate the ground already won, and to shake off the many stragglers, too blinded by their senses to see or heed the inner light. Time only could pick up and save the tiny increments, winnow some small but steady gains, and weld them through the passing years into better and more permanent form. Slowly but surely he plodded forward, not knowing whither he went. Many there were who could only marvel dumbly as he passed them by, lacking the brain which led him onward, blind to the light he followed. Little by little it must have dawned upon him that he was not like the beasts of the field, but that he stood in certain contrast to all things else, superior and aloof, in the world but not of it. Nor could he have escaped the immense importance of his hands, willing servants in a hundred different ways. One hand was better than the other, and he let it go at that; content to recognize the better of two things and call it right.

He could not have known how close he stood to the headwaters of all human achievement; he could not have known that history was in the making and that his progeny should be as the sands of the sea. He could not have dreamed that he was daily forging the material and intellectual weapons and accoutrement with which his children and his children's children for a thousand generations should gird themselves for mastery of the world, and which, all too often, they would turn against each other. His wildest phantasms could have given him no inkling of what the future might have in store, the heaped-up tribute brought by human hands. Still less was it possible to fathom the inner springs of action, the feelings which darkly stirred somewhere within him, the driving forces of which he was but dimly aware.

But primeval man, with all his natural frailties, could soon have recognized the essential nature and the sources of his own supremacy. His daily life would have taught him the value of his hands and what might be expected of them; as it would have brought about a fuller realization of the extent to which he could mold and fashion the things about him, and extend and multiply his resources. He would have learned that he could not put his trust in sheer weight of strength, nor hope to accomplish the desired results merely by the blind use of force. He would have realized ever more clearly that back of his hands and arms, somewhere within him, there was something which far outweighed his mightiest foes, something upon which he could lean in time of need, something which he could pit against his most perplexing problems. Slowly the accumulations of long experience would assume more definite form and many a nameless Nestor could teach his growing sons the young tradition;

> It is not strength, but art obtains the prize,
> And to be swift is less than to be wise.

As the hands had long been idle, awaiting the development of the brain which could employ them,. so the voice had been dumb and all but silent. The hands were ready when the brain found something to do, and likewise the mechanism for speech was ready when the brain found something to say.

The nervous control of the muscles concerned with speech is bilateral, the muscles on one side being connected with the opposite side of the brain. They are quite as ancient as any of the muscles of the limbs and in their primary functions, in feeding and breathing, their original nervous control is still unaltered. In their newer rôle, however, in relation to speech, but only for this purpose, they are presided over by a highly developed nervous mechanism, the speech center, which has its seat on that side of the brain which controls the favored hand. This unilateral control of bilaterally disposed and bilaterally acting muscles is most significant. It is part and parcel of that cerebral specialization which reveals itself most conspicuously in handedness. Its location on the left side, in the majority of cases, is to be looked upon as secondary to the functional superiority of this side of the brain, and that in a twofold sense. In the first place, this is the side of the brain most directly concerned with those peculiar activities, manual manipulations involving the higher mental faculties, the very nature of which would create a need for language and favor its development. In the second place, and probably of greater importance, was the rôle of the favored hand and arm, in supplementing and more sharply defining the earliest linguistic efforts. The fact that the speech center, so-called, is single and unilateral rather than double is an even more striking example of late functional specialization than is the predominant use of one upper extremity. In the case of the former, the peripheral, active organ is single and a unit in its activity, although made up of two symmetrical halves, belonging to either side of the body. In the latter case the organs are wholly separate, paired and entirely independent of each other. The original control of one limb is from one, the opposite side, of the brain; the original control of the muscles eventually used in speech, is, on the contrary, from both sides of the brain. If we are right in supposing that the brain sought and found expression in action before it did in speech, then we can hardly escape the conclusion that signs and movements were an early and persistent characteristic of primitive language. The use of them to-day is one of our oldest habits, as it is also the best evidence of their general utility and effectiveness. The development of spoken language must have provided a most powerful stimulus to all the intellectual faculties, quickening and refining the mental processes, and making for speed and economy.

Although there was doubtless a long period during which handedness was being developed, before the choice was finally settled on one side of the brain or the opposite hand, in the case of speech, as just noted, that period of uncertainty may have been much shorter, since the ground had been prepared, to some extent, in advance, and the essential principles had already been laid down. Henceforth the dominance of one side of the brain in both word and deed was assured, cerebral specialization had been established.

But there is another side to the picture which we have drawn, a much more somber side and marred by many shadows. We may not forget the soil from which man sprung, nor pass by his long infancy cradled in the dust of the ground. However high he may have reared his head against the sky, whatever crown he may yet place upon his own brow, he was deeply rooted in the earth beneath, his feet are still of clay. A child of sense and born of the flesh, his achievements, unique and remarkable though they were, could rise no higher than their source. With all his skill and insight, he lived in a material world, worked with material things, for material ends, animated by some passing whim or driven by physical desires. His various mental processes, even the highest of them, were at first little more than

transfigured bodily activity, his thinking was primarily a doing, and his motives still bore the deep imprint of their lowly origin. He was self-centered and naturally selfish, for the old Adam still hung over him with all but crushing force.

He had served a long and weary apprenticeship in training his brain and hands and lips to do his bidding, but a harder task awaited him in the clarifying and refining of the motives which were to actuate him. He was splendidly equipped, but that equipment might serve any purpose, either good or bad; power was his and the ability to accomplish things, but that power and ability had to be directed into proper channels; he had yet to learn how to use the forces at his command for the greatest good of all, he had yet to realize that might does not make right.

We can not wonder, then, if all his proud attainments and all his vaunted skill and ingenuity brought with them no immediate guarantee of commensurate uprightness and probity, no visible surety for those gentler qualities which make up the milk of human kindness. It could not have been otherwise. He was animal and selfish, before he was human and unselfish; but he also had been an animal immeasurably longer than he had been a man. His brain and his hands were his own, and their primary function was to serve him; acutely sensitive to his own wants, he was naturally slow to recognize the rights of others. If the conquest of crass material forces had been so slow and costly, how much longer before they could serve the common good in peace and equity. 'Tis hardly strange that the animal within should break through the thin veneer of human culture; that, drunk with new-found power and the prey to low desires, man should tear down his own temples and lay waste his own shrines, let loose the lightnings round his head or follow after strange gods to his own undoing. It was a hard school, but he had much to learn. Too often has he mistaken liberty for license and drunk the bitter lees of retribution. Too often has he called down upon his head the fierce denunciation of his fellow men, Swift's stinging satire in the tale of the Houyhnhnms. Too well and all too often has he merited the sulphurous sarcasm of Mephistopheles, who, in recounting for the Creator his impressions of the new world, of the new man and of his boasted power, could only say:

> Er nennt's Vernunft und braucht's allein,
> Nur tierischer als jedes Tier zu sein.

The little leaven, which many times seemed hopelessly submerged, was hidden in a vast amount of meal; it was yet a long time until Shiloh came.

The age-old struggle for supremacy, between brawn and brain, was fought out on many fields, with many diverse weapons. Its apogee is marked by that cerebral specialization whose outward sign we know as handedness. Language, and perhaps other intellectual attributes, likewise enjoy its benefits. It was like the contest between Ajax and Ulysses for the divine armor of Achilles. But again the outcome was never in doubt; the towering, insolent, bloodthirsty son of Telamon was but a mean match for the wise and cunning king of rocky Ithaca.

> Not by bulky size,
> Or shoulder's breadth, the perfect man is known;
> But wisdom gives chief power in all the world.

BOTANIZING ON BARRO COLORADO ISLAND, PANAMA

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OUR national engineering achievement in Panama has opened to the traveler a waterway with constantly shifting scenes of luxuriant tropical life. At about the middle of this enchanting fifty-mile journey through the canal he may observe on a promontory jutting against the waterway the following sign:

INSTITUTE FOR RESEARCH IN TROPICAL AMERICA
BARRO COLORADO ISLAND BIOLOGICAL LABORATORY
This island was set aside April 17, 1923, by the Governor of the Panama Canal as a natural park and biological preserve
TRESPASSING PROHIBITED

Barro Colorado Island, with its six square miles of tropical forest, is the largest island in Gatun Lake, the artificial 164 square mile sheet of water which constitutes the central part of the canal. The island is about eleven miles from Gatun Dam, which was built across the valley of the Chagres River to form the lake, and about the same distance from the equally famous Culebra Cut, where one hundred ten million cubic feet of rock and earth were removed to bring about the realization of the motto expressed on the official seal of the Canal Zone, "The land divided; the world united." Lying but nine degrees north of the equator, the island affords a fair sample of the biological wealth of the vast American tropical region. In the commodious laboratory erected by the National Research Council and several cooperating educational institutions, one can enjoy the comforts of civilization while investigating the primitive jungle of the tropics.

There has been much written about the birds, mammals and insects of this area.[1] The forest which furnishes the setting for this vast array of animate activity is worthy of study. It is classified by botanists as a rain forest. The vegetation is not so fully adapted to humid conditions, however, as is that of the Amazon Valley. It has some of the characteristics of that other tropical forest type, the monsoon forest, which attains typical development in British India and other regions with an annual climate fluctuating from extreme dampness to extreme dryness. The island receives about 115 inches of rainfall annually, only ten to fifteen of which fall during the first five months. The dry season is far less prolonged and less severe than in the typical monsoon region, yet it is distinct enough to cause a definitely periodic behavior, with a well-marked leafless period in a number of the tree species. Oceanic conditions prevent extreme temperatures, the range being from 69 to 89 degrees Fahrenheit.

About half of the island, the portion most remote from the laboratory and canal, is splendid primeval forest. The half nearest the laboratory and canal has not, except in ravines, any trees of more than about a foot in diameter, hence presumably it was in cultivation up to about fifty years ago. A rusty dump-cart lying inverted along one of the trails of this portion recalls the days when the French pioneers tried to carry out the century-old vision of a canal across the isthmus. One wonders how it

[1] See George Shiras 3d, "Nature's Transformation at Panama." *National Geographic Magazine*, August, 1915; and Frank M. Chapman, "Who Treads our Trails?" *National Geographic Magazine*, September, 1927.

LABORATORY OF THE INSTITUTE FOR RESEARCH IN TROPICAL AMERICA

PERCHED ON A HILL OVERLOOKING THE BAY AND THE FORESTED VALLEYS ON EITHER SIDE IS THIS NEAT AND COMFORTABLE LABORATORY BUILDING. FROM THE LABORATORY NO LESS THAN SIXTY OF THE NATIVE TREE AND SHRUB SPECIES MAY BE OBSERVED.

A VILLAGE IN RURAL PANAMA

UP THE CHAGRES RIVER, ABOUT TWO MILES BEYOND THE BORDERS OF THE CANAL ZONE, THE QUAINT LITTLE VILLAGE OF SANTA ROSA PURSUES ITS PEACEFUL RUSTIC WAYS. CANE STALKS FROM NEAR-BY MARSHES PROVIDE THE WALLS, PALM LEAVES THE THATCHED ROOFS. THE ONLY PLACE OF BUSINESS IN THE VILLAGE IS A SALOON AND GENERAL STORE WITH A CHINESE PROPRIETOR.

DISPLAY OF TROPICAL FOLIAGE SEEN FROM THE RESEARCH LABORATORY
ABOVE IS THE COROZO PALM, A SINGLE LEAF OF WHICH HAS A LENGTH OF FORTY FEET. BELOW, AT LEFT, A RELATIVE OF BRAZIL-NUT; IN CENTER, THE BANANA; AT RIGHT, THE PAPAYA.

got to this five hundred-foot elevation. Probably the peasants who cultivated the area made some use of it. But today the area in which it lies is being rapidly reclaimed by the jungle. The French failure in Panama followed their success in Suez. But we can scarcely imagine two regions affording a more striking contrast than do Suez and Panama. One of them is a barren sandy desert, the other a luxuriant humid forest. We can not, therefore, wonder that De Lesseps and his colaborers, having conquered one situation, were unable to cope with the very different conditions in the other.

Barro Colorado, signifying in Spanish "red clay," was the name of this region before human handiwork made it an island. Its subsoil is of a vivid red and is underlain by reddish sandstones and conglomerates. History tells us that the courageous but unprincipled British pirate, Henry Morgan, as he marched across the isthmus to raid Panama City, was repulsed for a time by a band of Panamanians stationed at Barro Colorado, but that the resistance finally broke down and permitted the raiders to carry out their dastardly ambition.

The species of seed-plants and ferns thus far listed for the island number about 725. Much of the area has not yet been thoroughly explored, hence the whole number probably exceeds one thousand. This is approximately twice the number for an average similar area in the temperate zone. Moreover, the relative showing of the different growth forms, termed by botanists the plant spectrum, is quite different. Of the eleven hundred plant species of a typical Michigan county, about 16 per cent. are trees and shrubs, while of the Barro Colorado species about 52 per cent. are trees and shrubs. Plant families that are mainly herbaceous in our flora—such families as the buckwheat, the spurge, the meadow beauty, the morning glory, the nightshade, the madder—are prevailingly shrubs and trees in the tropics.

In consequence of this great diversity of woody plants, one can not so easily pick out dominant trees as in our

own region. In the latter we speak of beech-maple forests, oak-hickory forests, tamarack bogs, pine dunes and the like, but in Panama we should probably have to list at least twenty-five species among our dominants. From a point of vantage, such as the laboratory building, one can count at least sixty species of trees and large shrubs. Rarely do more than two or three trees of a species appear at one time to the observer on the forest trail.

Another outstanding fact is the great size of some of the trees. The abundance of smaller as well as larger types is such that the large trees are not particularly crowded. On a walk of a kilometer (one half mile) through the virgin forest, the writer counted 150 trees having a diameter of two feet or over. One might do better in almost any of the few remaining primeval forests in the United States. But the big trees—some of them at least—are exceedingly big. A specimen of "spiny cedar" (*Bombacopsis Fendleri*) has a basal circumference, around the outside of the huge buttresses, of about 190 feet. Its top rises like a huge dome above the forest roof and spreads to a diameter of two hundred feet. At the foot of such a giant a mere man dwindles into insignificance. The flat triangular buttresses which brace the base on all sides sometimes meet at the outer ends in such a way as to form fair-sized rooms with high perpendicular walls. One of these rooms is dark enough to provide a comfortable home for bats.

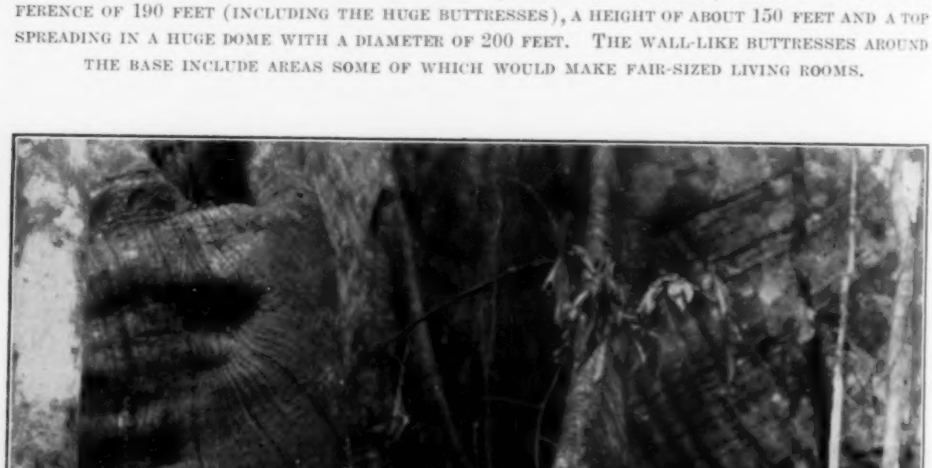
In height the trees are not equal to those of the conifer forests of our Pacific states. The tallest are about 150 feet high, the average of the forest canopy probably not exceeding one hundred feet. It would seem that Bombacopsis and the few other species of tall-growing trees have so much competition in early life with less tall-growing forms that relatively few of them survive to become tall trees. Then, as they out-

SOME BIG LEAVES OF THE RAIN FOREST

LEAVES OF TROPICAL PLANTS ARE OFTEN MUCH LARGER THAN THOSE OF TEMPERATE SPECIES. THE LARGEST ARE THOSE OF A PALM (EXTENDING DIAGONALLY ACROSS THE VIEW), AND OF A TREE FERN (UPRIGHT, AT LEFT). THE LARGEST UNDIVIDED LEAVES ARE THOSE OF THE BANANA (AT RIGHT) AND SOME OF ITS WILD RELATIVES (NEAR CENTER).

BIGGEST TREE OF THE ISLAND JUNGLE

THIS MAGNIFICENT SPECIMEN OF "SPINY CEDAR" (*Bombacopsis Fendleri*) HAS A BASAL CIRCUMFERENCE OF 190 FEET (INCLUDING THE HUGE BUTTRESSES), A HEIGHT OF ABOUT 150 FEET AND A TOP SPREADING IN A HUGE DOME WITH A DIAMETER OF 200 FEET. THE WALL-LIKE BUTTRESSES AROUND THE BASE INCLUDE AREAS SOME OF WHICH WOULD MAKE FAIR-SIZED LIVING ROOMS.



NEAR VIEW OF THE BIGGEST TREE

TWO BUTTRESSES MEETING IN CENTER OF THE VIEW FORM A ROOM SO DARK THAT IT IS OCCUPIED BY BATS.

BIGGEST TREE TEN FEET ABOVE GROUND

NOTICE THE NATURE OF THE HUGE PLANK BUTTRESSES, THE PROFUSION OF LIANAS WHICH ENABLE ONE TO CLIMB WELL UP THE TRUNK, AND THE CHARACTERISTIC HORIZONTAL GROWTH LINES ON TRUNK AND BUTTRESSES. THE LIGHT PATCHES ARE LICHENS. THE SPREADING BRANCHES CONSTITUTE A VERITABLE BOTANICAL GARDEN WITH A WEALTH OF FERNS, AROIDS, ORCHIDS, PEPEROMIAS, ETC.

grow their neighbors, the tendency is to spread outward rather than to continue upward.

Many of the other trees resemble Bombacopsis in the development of basal buttresses. Winds, which are frequently severe, will not easily overturn a tree that is fortified in this manner. A similar strengthening device is the prop root system, which is found about the base of trees of a number of species, but which is most beautifully developed in the stilt palm, a tall graceful tree abundant in the forest.

A striking feature of the tropical forest is the great size of many of the leaves. The largest is the pinnate leaf of the Corozo Palm, measuring forty feet from base to tip. The banana and several of its wild relatives possess very large undivided leaves.

At various times during the year different trees are ablaze with a wealth of colored blossoms. The dry season is preeminently blossom season. At this time there are few rains to wash away the pollen, and the sparseness or absence of foliage on some of the trees permits greater freedom in pollen distribution. But even during the rainy months bright patches appear here and there in the forest, as various species display the purple, gold or red of their flowers. The effect is heightened by the gay plumage of parrots, toucans and other brightly colored birds and the intense blue of the Morpho butterfly, while the call of the wild turkey and the cry of the howler monkey make vivid the realization that one is indeed in the abode of life.

The rain forest is noted for climbing plants. Great festoons of stems, perhaps ten or more species on the same tree, hang down from the branches or form tangles along the trunks. To

secure light is the great problem in such a forest and these plants get their foliage to light without the expense of constructing a self-supporting trunk. Many of these climbers retain life so tenaciously that, if cut off, the upper part sends down new roots and re-establishes its connection with the ground. Climbers of the twining type often strangle the tree that supports them by constricting its food-carrying tissues.

Taking similar advantage of the better illumination afforded by a position above ground is a noteworthy group of hemiepiphytes (half-way epiphytes, or living upon another plant in early life only). These include several species of strangling fig and some members of other families. These plants generally begin life on a branch high in the supporting tree. Roots extend down along the trunk of the supporter to the ground. These roots branch out and rejoin one another in such a fashion as to form a network that may completely enmesh the supporting trunk. The mesh may finally close up, leaving only the fig tree visible, while the supporting one is wholly imbedded within it. Strangled till growth in diameter is no longer possible, our original tree may die, leaving only the strangler.

FRENCH DUMP CART IN SECOND GROWTH FOREST

MUTE EVIDENCE OF A GOAL PURSUED THROUGH SEVERAL DECADES AND FINALLY OVERWHELMED BY THE DISEASE-BEARING MOSQUITO. THIS SITE, FOUR HUNDRED FEET ABOVE THE LAKE, MAY HAVE BEEN THE HOME OF A BANANA-GROWER WHO MADE SOME USE OF THE CART AFTER THE FRENCH ENGINEERS HAD ABANDONED IT. THIS PART OF THE ISLAND IS NOW COVERED WITH A DENSE TANGLE OF SHRUBS AND VINES AND MEDIUM-SIZED TREES.

THE BIG TREES OF THE FOREST ARE FESTOONED WITH LIANAS

CLIMBING PLANTS OF MANY SORTS TAKE ADVANTAGE OF THE CHANCE FOR LIGHT AFFORDED BY THE SPREADING TOPS OF THE BIG TREES. SOME OF THE STEMS ARE NOT IN CONTACT WITH THE TREE-TRUNK, SUGGESTING THAT THEY CLIMBED UPON OTHER TREES WHICH HAVE SINCE DISAPPEARED. THE SLENDER CORDS ARE ROOTS OF EPIPHYTIC AROIDS EXTENDING DOWNWARD TO CONNECT THE PLANT WITH THE SOIL.

An epiphyte ("upon plant") is a plant that uses another merely as a support, not as a source of nourishment. Epiphytes are exceedingly numerous in the rain forest. The branches of a big tree form a veritable botanical garden, occupied by ferns, aroids, orchids, cistern-plants, cacti and various other plants. As the writer walked along the

trail with a vague longing for the climbing ability of his brethren of the monkey tribe so that he might explore these gardens, he found a tall tree which, recently broken by the wind, was lying across the path. On it were found ten kinds of epiphytes and eight kinds of climbers. A violent attack ensued as he proceeded to gather epiphytes from one conspicuous clump which had been high in the tree top, for a colony of stinging ants had taken up its abode in the matted roots of the plants.

Aroids (relatives of our Jack-in-the-pulpit) are very numerous and seem to prefer the tree-top situations, both as climbers and as epiphytes. Some have huge leaves and loom up conspicuously on the trees. One frequently sees ferns of the bird's-nest type, *i.e.*, with the broad leaves arranged around their place of attachment in such a fashion as to form a basket or nest. This collects humus and helps to retain water for the plant. The cistern-plants (bromelias or relatives of the pineapple) have a more

SUPPORTING ROOTS OF THE STILT PALM

TWIN SPECIMENS OF THE STILT PALM (*Iriartea exorrhiza*) SHOW THE INTERESTING FASHION IN WHICH THIS TREE HAS SOLVED THE PROBLEM OF SUPPORTING ITS TALL SLENDER TRUNK. THIS IS ONE OF THE MOST ABUNDANT AND BEAUTIFUL PALMS OF THE FOREST.

HOW TWINERS AFFECT TREES

THE CONSTRICTION BY A TWINER OF THE FOOD TUBES OF THE TREE ON THE RIGHT HAS CAUSED THE FOOD TO BE UTILIZED IN EXCESSIVE GROWTH JUST ABOVE THE COILS, GIVING THE TRUNK A CORRUGATED APPEARANCE. THE TWINER ITSELF HAS DIED AND DECAYED, DEATH BEING PROBABLY DUE TO STRETCHING BY THE ENLARGEMENT OF THE TREE. THE GRACEFUL STEM OF A PALM IS SHOWN ON THE LEFT.

pronounced receptacle which catches the rain-water and retains it until it can be absorbed by the plant. Epiphytic orchids are numerous. These plants have long attracted the attention of the collector because of their peculiar flower structure, very highly specialized for the secural of cross-pollination by insects. One common stump-inhabiting orchid has concealed within its large yellow bonnet-like flower a prominent trigger. The touch of the insect against the trigger causes the pollen mass to be dislodged and thrown with force toward the opening of the flower. Attached to this mass is a sticky gland which adheres to the insect. The pollen mass is thereby carried to the next flower visited and thrust against the stigma. . Orchids have air roots pressed against the limb on which they grow or hanging freely in the air. The outside layer of the root consists of porous cells that take up water like blotting paper.

Most epiphytes have a striking resistance to drought. Living as they do without a soil connection, they would not be able to endure the inevitable dry period without such resistance. In some cases, the resurrection plant type, the leaf is able to dry and to resume activities when again soaked with water. To this type belong the filmy ferns, which have such very thin delicate leaves as to appear like water-plants. In others, the leaves are thick enough to store water and waterproofed enough to prevent its loss. Certain fern and aroid leaves placed in the laboratory attic just under the corrugated iron roof, where midday temperatures become very high, remained for a month without appreciable loss of water.

A FERN-FRINGED BANK OF THE OLD FRENCH CANAL

AN INTERESTING BIT OF THE WORK OF THE FRENCH COMPANY BRANCHES OFF THE PRESENT CANAL. HERE IT WAS PLANNED TO PLACE ONE OF THE LOCKS. THE CONTINUAL BEATING OF WAVES IN THE WAKE OF VESSELS EXPOSES THE SANDSTONE, WHICH IS HERE GRACEFULLY DROOPED WITH THE FERN, *Nephrolepis pendula*, A NEAR RELATIVE OF THE WELL-KNOWN BOSTON FERN.

AN INTERESTING PARASITE FROM BARRO COLORADO

Apodanthes Flacourtiae IS PARASITIC ON A SPECIES OF XYLOSMA. THE WHOLE PLANT IS INSIDE THE HOST WITH THE EXCEPTION OF THE LITTLE WHITE FLOWER THAT BREAKS THROUGH THE BARK. THIS PLANT BELONGS TO THE RAFFLESIA FAMILY, A GROUP HITHERTO UNREPORTED FOR CENTRAL AMERICA.

One can scarcely comprehend the difficulties that beset the botanist who would identify the trees of the tropics. The nearest leaves may be one hundred feet from the ground. If they are large enough, or have striking characteristics, he may be able to recognize them by using an opera glass. But so many trees have leaves so provokingly ordinary that they are not recognizable at a distance. He then looks about for leaves that may have fallen to the ground. He picks up a leaf. The question then arises whether it came from the tree itself, from some one of the twenty sorts of plants climbing or nestling upon it, or from some one of the numerous tree species crowded around the one in question. He defers the solution for further evidence, which may not be easily secured.

Barro Colorado Island has twenty-five miles of shore-line. It is along

INHABITED STUMP IN GATUN LAKE

THE WRECKAGE OF TREES, DESTROYED WHEN THE WATER WAS TURNED IN BEHIND GATUN DAM, IS OFTEN COVERED WITH EPIPHYTIC PLANTS. AT THE LEFT IS AN AROID (*Anthurium rigidulum*), ON THE RIGHT IS A REMARKABLY THICK-LEAVED TREE (*Clusia* SP.). A LARGE COLONY OF WASPS SUGGESTS CAUTION ON THE PART OF THE COLLECTOR.

A TREE ALIVE AFTER THIRTEEN YEARS OF FLOODING

THIS LARGE SPECIMEN OF ***Bombacopsis Fendleri*** IS ONE FOURTH MILE FROM THE NEAREST SHORE. IN SPITE OF HAVING STOOD IN SIXTY FEET OF WATER SINCE THE TIME OF THE CANAL CONSTRUCTION ITS BARK HAS HEALED AT THE WATER LEVEL AND HAS SENT DOWN ROOTS ENOUGH TO KEEP ALIVE A FEW TWIGS SCATTERED OVER THE BRANCHES.

these shores that one can do the most profitable plant collecting. In mid-forest the trees are so high that the collector must be content with leaves and flowers that have fallen upon the ground. But along the shore, practically all the foliage comes down to the water's edge, where it can easily be gathered by the botanist who paddles along in an Indian log canoe and is equipped with a pruning hook on a long pole. This newly formed shore gives one an excellent opportunity for the study of the adjustment of plant life to new environments. Thousands of trees were flooded and

A MARSH ISLAND IN GATUN LAKE

ON THE SIDE OF BARRO COLORADO ISLAND, AWAY FROM THE AGITATION CAUSED BY CANAL TRAFFIC, HUNDREDS OF LITTLE ISLANDS OF MARSH GROWTH ARE DEVELOPING. MANY OF THEM STARTED ON STUMPS OF THE DROWNED TREES. THE PRINCIPAL PLANTS ARE CAT-TAIL AND MARSH FERN.

killed. Many of the plants lodged on their branches were forced to give up because of the intense sunlight and the loss of bark from the dead trees, but some of the more hardy ferns, orchids and aroids remain. A new type of vegetation, the swamp type, has invaded the area. In the more quiet waters on the side of the island away from the canal are hundreds of little islands made up of masses of cat-tail, marsh fern, arrow-head, hibiscus, sedges and other plants. Some of these islands had their origin on a stump coming up to the water surface, others on places where the soil comes

A LARGE-LEAVED AROID

Anthurium maximum IS TYPICAL OF A GROUP OF RAIN FOREST PLANTS WHICH, FORSAKING THE GROUND, PERCH WHERE LIGHT IS PLENTIFUL. USUALLY IT GROWS ON TRUNKS OR BRANCHES OF TREES, BUT THIS SPECIMEN OCCUPIES THE TOP OF A LARGE ROCK. LACKING ANY CONNECTION WITH SOIL WATER, IT MUST BE FITTED TO WITHSTAND DROUGHT, HENCE THE FOUR-FOOT LEAVES ARE SO LEATHERY AND WATERPROOFED THAT IT TAKES A MONTH OF DRYING TO MAKE ANY IMPRESSION UPON THEM. THE FRUIT CLUSTERS, TWO OF WHICH HANG FROM THE CROWN, ARE BUILT ON THE SAME PLAN AS THOSE OF JACK-IN-THE-PULPIT, SKUNK CABBAGE OR CALLA.

almost to the water-level. The parts of Barro Colorado next to the canal are subjected to considerable agitation of the water, for the waves generated by passing vessels strike and erode the shores. Swamp formations are almost lacking on this side, but instead there are lake bluffs with a characteristic vegetation. Trees are uprooted, the logs drifting into and filling the shallow bays.

Thorny-stemmed trees are abundant. He who reaches a hand to the nearest palm trunk to steady himself as he walks through the forest must beware, for palms of some species are bristling with thorns. Prickly ash, known only as a shrub in our temperate climate, is represented in the tropics by several large trees with broad-based spines.

Ferns attain their greatest profusion on tropical mountain-tops. Our island,

however, has nearly one hundred species, belonging to nine different families. This is a good showing for a sea-level forest. The most striking of tropical ferns are the tree-ferns. Barro Colorado has three species belonging to this family. Representatives of one species stand thirty feet high in some of the ravines.

The attention of the plant lover is always attracted by those peculiar flowering plants which lack chlorophyll, and hence secure their food by methods other than that used by the ordinary green plant. These are parasites, which get their food directly from living plants, and saprophytes, which get their food from decaying matter in the soil, usually with the aid of a fungus which occupies the root system. The former are represented in the northern United States by dodder, mistletoe and beech-drops; the latter by Indian pipe and coral-root orchid. Aside from fungi, parasites are not numerous in the moist tropical lowlands. But the writer had the privilege of finding one of great interest. In the forests of the East Indies there appears on the trailing stem of a woody climber of the grape family an enormous blossom, sometimes a meter in diameter. The remainder of this strange plant, known as Rafflesia, is entirely within the stem of its host. The Barro Colorado plant is a small member of the Rafflesia family, displaying vertical lines of delicate white waxy flowers, which burst through the bark of the small tree serving as host to the parasite. Its discovery gives us the first record for this family in Central America. As one goes through the big forest he frequently encounters a delicate little leafless plant of a pale Venetian pink, springing up singly or in pairs from the rich leaf mold. This plant gets its food much as does the Indian pipe, *i.e.*, by cooperation with a fungus, which absorbs decaying matter from the soil, delivering part of it to our delicate little saprophyte. The plant is Ophiomeris, of the Burmannia Family, and is known only on Barro Colorado, where it was discovered two years ago.

SPINY TRUNK OF THE FAN PALM

SEVERAL OF THE PALMS AND OTHER TREES OF THE FOREST ARE ARMED WITH FORMIDABLE SPINES, BUT THOSE OF *Acanthorrhiza Warscewiczii* ARE THE LONGEST AND SHARPEST.

OLDEST KNOWN TREE OF BARRO COLORADO

THIS PETRIFIED STUMP, RECENTLY UNCOVERED BY EROSION, TELLS OF A HUGE FOREST DENIZEN OF SEVERAL MILLION YEARS AGO. THE TREE WAS A METER IN DIAMETER, COMPARING VERY WELL WITH THE AVERAGE LARGE TREE OF TO-DAY. THE HOLLOW CENTER ENABLES THE STUMP TO SERVE AS A FLOWER POT FOR SEVERAL MODERN PLANTS.

With its hundreds of tree species struggling for the same area, its dozens of climber and epiphyte species clinging to the tree tops to secure a place in the sun, its profusion of bird, beast and insect life, its innumerable types of ticks, lice, fleas, tapeworms and other animal parasites which live upon the different animals, its daily surge of plant and animal activity, the moist tropical region offers the most excellent field in the world for the study of nature in the making. It is no wonder that in pursuit of their studies of nature in the moist tropics, Charles Darwin and Alfred Russel Wallace were convinced of the reality of evolution and were led to an appreciation of the struggle for existence and the survival of the fittest as factors of importance in the explanation of the process.

The student of tropical life, however, does not find every organism perfectly fitted for its place in the world. With such great diversity, we could hardly expect equal degrees of fitness. On stepping outside the laboratory one rainy day, the writer saw a portion of the forest roof in the valley below him topple and heard a great crash. A visit to the place showed that a big tree of the ginseng family had broken into a thousand fragments. The brittleness of the wood, the increased weight of the water-soaked leaves and blossoms, the loosening of the soil by a week of unusual rainfall had conspired to effect in a moment the ruin of an individual which had been a century in building. Every day the jungle offers evidence that some species are in certain respects lacking in fitness, yet are not unfit enough to disappear entirely from the scene.

One is likewise strikingly impressed with examples of greater fitness. One day while paddling about the shores in the hollowed log canoe, the writer saw far out in the lake a big tree that seemed to have an unusual number of orchids growing upon its limbs. On going

ONCE AN EPIPHYTE, NOW A FOREST GIANT

THIS MAMMOTH FIG TREE (*Ficus costaricana*) STARTED LIFE IN THE CROTCH OF A TREE OF THE BRAZIL-NUT FAMILY. DROPPING ITS ROOTS TO THE GROUND, IT DEVELOPED A LARGE TRUNK ENTIRELY SURROUNDING THE TREE THAT SUPPORTED IT IN INFANCY, BUT SOME OF THE BRANCHES OF THE LATTER COULD BE SEEN ABOVE THE RANGE OF THIS PHOTOGRAPH. NOTICE A PROP ROOT IN THE FOREGROUND AND ANOTHER AT THE RIGHT.

SAPROPHYTES IN TROPICAL RAIN FOREST

AT THE LEFT IS *Ophiomeris panamensis*, AN INTERESTING AND RARE PLANT OF THE BURMANNIA FAMILY. AT THE RIGHT IS *Leiphaimos albus* OF THE GENTIAN FAMILY. ONE SPECIMEN OF OPHIOMERIS IS IN ITS ORIGINAL POSITION, THE OTHER PLANTS HAVING BEEN TRANSPLANTED FOR THE PICTURE. THESE PLANTS, WITH THE COOPERATION OF A ROOT FUNGUS, MAKE USE OF THE DECAYING MATTER OF THE SOIL.

nearer it was a real surprise to note that the tree itself was alive. It was a Bombacopsis, of that species to which the biggest trees of the forest belong. Standing in about sixty feet of water for the past thirteen years, with its trunk flooded to the crotch, the bark which had died and disappeared below the water had healed over at the water-level and had sent into the water a few feeble roots. These roots have sustained a few twigs and have enabled the tree to hold the slender thread of life under conditions which would utterly discourage most mortals. Perhaps this explains why Bombacopsis gets to be so large a tree in the forest. At any rate, we have here presented an example of hardihood and tenacity that would be difficult to equal—an example that should induce us in the midst of discouragements to push forward more thoroughly impressed with the beauty and the majesty of life.

NATURAL HISTORY BY RADIO[1]

THE LARGEST REPTILES

By Dr. THOMAS BARBOUR

MUSEUM OF COMPARATIVE ZOOLOGY, CAMBRIDGE

MANY millions of years ago there were no warm-blooded animals on the face of the earth, and the principal creatures to be met with on land, at sea, and in the air were reptiles. There were gigantic, browsing, lizard-like reptiles, bulky bodied and slow moving, which reached a length of 150 to 180 feet and which would weigh more than several elephants. There were great hopping kangaroo-like forms, some of which had long tearing teeth. These fed upon the passive, sluggish and inoffensive types—large though these were. Then there were gigantic armored reptiles which looked more as the rhinoceros looks, and in the sea, schools of porpoise-like reptiles dashed after their finny prey—for fishes, of course, were abundant even in these ancient times. There were no birds, but their place was taken by flying reptiles which ranged in size from little sparrow-like creatures to enormous forms whose spread of wing would rival or exceed that of the largest flying birds which we know now.

Times have changed slowly but surely, for many millions of years have passed and the reptiles are not now the dominant creatures which they were once, and to-day, with ever-accelerating pace, conditions change faster and faster. The tropical jungle, over vast areas, is being cleared for the planting of such products as sugar, coffee, rubber and bananas, and with the clearing of the forest the old jungle life goes. Millions of men, whose fathers hunted with the bow and arrow, in many parts of the world to-day have modern rifles and shotguns, and, contrary to what many people believe, there is no alligator or crocodile so heavily armored but that the modern rifle can penetrate through and through his body, wherever he may be hit.

We have started to talk about crocodiles and, while nowhere in the world are there to be seen such monsters as could have been found even a hundred years ago, nevertheless in the tidal swamps and marshes of the East Indies there are probably still a few old crocodiles over 20 feet in length. As I write these remarks, I am looking at the skull of the largest recorded crocodile in the world. It was killed 100 years ago near Manila by Mr. Russell, one of the old firm of East India Merchants. This great crocodile had long been known and was a terror to every native. Its lair was near a ford, and it had a way of pulling down horses and men as they rode across the river; sometimes frequently, and sometimes not for long stretches of time. Finally, by the concerted efforts of Mr. Russell, a French companion and a host of natives, the great beast was wounded, lassoed, drawn up on the bank, and dispatched. This great crocodile was almost exactly 30 feet in length and was no less than 11 feet around the body just behind his fore limbs. Mr. Russell brought the skull back and gave it to the Boston Museum of Natural History, where it was preserved for about 80 years, when it was transferred to the Museum in Cambridge.

[1] Broadcast under the auspices of the Boston Society of Natural History under the direction of Dr. Francis Harper.

No alligator ever approached this size. In the past there have been many 16-foot alligators in our southern states. Today a 12-foot alligator is rare, and the great majority are 6 to 8 feet long. During the last two or three decades, thousands upon thousands of alligators have been killed for their hides and many thousands more have been left without breeding grounds by the draining of the Everglades and other swamps.

Many winter visitors when they go to Florida bring young alligators as pets and these little animals, kept under unfavorable conditions as they perforce must be in the north, grow very slowly or not at all. Kept out doors in a garden fountain during the summer time they grow rapidly if abundantly fed, but during the rest of the year they do not grow at all. This is probably one of the reasons why people believe that a really big alligator must be hundreds and hundreds of years old. Big alligators may live for a long time. Of course no one knows definitely. We do know, however, that under really favorable conditions of climate and food they grow very fast. Little alligators hatched in the reptile house of the Zoological Park in New York in 1900 were six feet long and weighed nearly 75 pounds at the end of six years. An alligator, just under seven feet, which came to the park in the autumn of 1899 was eleven and a half feet long by the autumn of 1905. This animal may have been perhaps fifteen years of age. So that we can say with certainty that a twenty year old alligator is fully grown. We have no such accurate data for the crocodile, but there is no reason to suppose that its rate of growth would differ very much.

It is not generally known that there is an alligator very much like our southern species found in east central China. It seems to be a smaller form, growing only to be four or five feet long. This small size may, however, be due to the fact that it is constantly hunted and persecuted by the Chinese who use almost every part of the animal for medical purposes. If, as is not impossible, they were much more abundant and grew to a far larger size generations ago, it is not improbable that this alligator was the prototype of the Chinese Dragon which was so abundantly used in decoration and so often referred to in Chinese folklore and mythology. It is interesting that the Chinese 'gator bears two names You Lung and Tou Lung, both of which combinations signify a dragon. Unlike our species, the Chinese alligator is very shy, coming out only after dark and preying largely on the mongrel dogs so common everywhere in China. Our own alligators love to bask in the sun, but where persecuted they too tend to become nocturnal.

You have all heard of the great tortoises of the Galapagos Islands. These, with their cousins found on some small islands in the Indian Ocean, are the largest of all the land turtles. We know that they live to very great ages, for there have been specimens in captivity at Cape Town, in Ceylon, at St. Helena, and in Mauritius for over a century. The largest of these turtles will weigh perhaps 450 pounds and be about 4 to 4½ feet long and perhaps 3 feet high—great, ponderous, unwieldy creatures. There is a fossil turtle known from India which was very much larger than this.

Sea turtles are larger than the existing land tortoises (the name turtle and tortoise are perfectly interchangeable terms). The great turtles which live on the surface of the tropical seas and occasionally wander elsewhere, may be 8 or 9 feet long and weigh 1,400 to 1,500 pounds.

The majority of present-day lizards throughout the world are small creatures, but a few years ago a gigantic lizard was found to persist on a little island called Komodo, far to the southeast of Java, and this great brute

which may grow to perhaps nine feet in length, is said to kill pigs and even at times to attack the native ponies. Recent expeditions have taken many of these monitors, none of which reached the size indicated by the first rumors of their existence. Except for this giant there are but few lizards more than 4 feet in length. These are found among the families of the old world monitors, all related to the Komodo Island lizard, and amongst the iguanas of tropical America. Such iguanas live in trees, are vividly colored and rather terrifying to look at, with their crests of long spines and horny tubercles. Never-the less they are very delicious when properly cooked and are eaten by very many different peoples, including the writer, who has enjoyed them on many occasions.

Snakes do not grow nearly as long as some travelers tales would have us believe. The longest poisonous snake is the great King Cobra of southern Asia which once in a great while reaches 18 feet, but the crushing non-poisonous species grow much larger than this. The Pythons (sometimes wrongly called Boa-constrictors) in the Malay jungles grow to be about 30 feet at most. The largest of the true Boa-constrictors are very much smaller, probably never reaching 18 feet, although in the rivers of South America the Anaconda grows to the greatest size of any living snake, reaching 35 and possibly even 40 feet in occasional cases. Such a snake as this would weight about 325 pounds or perhaps even more.

Under what might be called normal conditions the snakes and lizards, as well as turtles and crocodiles, lay eggs. These may be buried in the sand or mud; a nest of decaying vegetable trash may be laid up in a sunny spot; the eggs may be buried in sand banks, in hollow trees or in cavities in rotten logs. They are hatched by the heat of the sun, aided frequently by the heat generated by decaying vegetable matter. I am often asked, "How is it that a good many snakes and a few lizards have living young?" and the answer is simply this; that in a certain number of forms the eggs are retained within the body of the parent until they hatch. The young emerge and the egg capsules may be cast forth later on or be absorbed. Generally speaking, most poisonous snakes of the viperine type, *i.e.*, those that have long movable fangs, have living young, but some harmless snakes, as our common water snake, for instance, also bears an enormous living brood, sometimes even fifty or sixty. The habit, while common with snakes, is a very rare one among lizards and is unknown among tortoises and crocodiles.

It is perhaps needless to say that snakes do not swallow their young to give them protection, although I know that a lot of you have friends that know someone who saw this happen. I hear of such cases all the time, but curiously enough the naturalists who are in the field year in, year out, observing the habits of reptiles in every part of the world have never yet seen a single case where this occurred. Sometimes, during the common country pastime of beating a useful snake to death with a club, the young about to be born may be squashed out of its body and, of course, the average person can only interpret this by assuming that the little snakes got where they were found by running down their parent's throat after they had been frightened. This yarn, until more evidence is accumulated, will have to be classed in the same category with the story of the hoop snake, and the coach-whip snake and similar whimsies.

The part of the world in which we live—these New England States—are not very plentifully populated with reptiles. None of the giant species occurs. The poisonous snakes have almost completely disappeared except for a few scattered localities where an occasional

copperhead or rattlesnake may be found. Our little pond turtles and land tortoises are familiar to every country boy and girl, although there are many who have never seen a lizard alive, unless it be some hapless little captive brought home from a trip to the south. Nevertheless I know that you all know enough about the general form of these different sorts of reptiles to be able, in some degree at least, to see in your mind's eye the giants of the hot, moist, equatorial lands.

WHALES AND WHALING IN NEW ENGLAND

By Dr. GLOVER M. ALLEN

BOSTON MUSEUM OF NATURAL HISTORY

THE early history of New England is very closely bound up with the whale fishery, an industry to which our early colonists applied themselves with such zeal that at one time in Massachusetts Bay it bade fair to be one of their best sources of revenue. The historic *Mayflower* herself, even before she sailed on the eventful voyage to Plymouth Bay, had apparently been a whaler and in after times was for a number of years engaged in the Greenland whale fishery. When, therefore, in 1620, the Pilgrims found an abundance of whales "playing hard by," many of them were eager to undertake their pursuit, especially as there were among the ship's company a number of men skilled in the Arctic whaling, a much more difficult profession. The whales that frequented our shores in such numbers three hundred years ago were of the kind called "right whales," a peaceable and relatively slow moving species, provided with a thick coating of fat or blubber over its body, and with long narrow blades of whalebone hanging in double rank from the roof of the mouth. These whales were migratory, appearing on our coasts in late October from waters farther east and north. No doubt many remained all winter while others went still farther south, even to the Carolina coast, and returned northward in spring, especially in April and May, often at this season accompanied by their young. In these early years dead whales were so often cast upon shore, that laws and regulations for deciding their ownership were constantly being enacted. For some years, the coast towns of southern Massachusetts regularly appointed a "whale viewer" whose duty it was to examine all such "drift" whales as they were called and to record all marks or wounds upon them, as well as to keep a record of whales reported to have been wounded but lost, so that in the case of their being subsequently cast ashore, the rightful owner might be enabled to claim them. In 1662 it was voted by the town of Eastham that a portion of the proceeds of all such whales as drifted ashore dead from natural causes, be appropriated for the support of the ministry. Subsequently, in 1702, the Reverend John Cotton, of Yarmouth, received no less than £40 from the amounts realized for whales so cast up. The pursuit of whales in small boats from shore continued for over one hundred years until the numbers of those frequenting our coasts were very much depleted and they have never since recovered. Most of the pursuit of whales was at first in small boats from the shore, and in this a good many of the Cape Cod Indians were regularly employed, becoming skilled in this work. Gradually, however, the colonists began to fit out small

vessels for the pursuit of whales off shore, and it was in the course of one of these voyages to the south of Nantucket, that Sperm Whales were encountered in the warmer waters of the Gulf Stream. So that when, about 1750, the pursuit of "right whales" near shore was no longer profitable, there were men and vessels ready to go on longer cruises for the sperm whales. This industry developed rapidly. In 1774 ships from Nantucket first crossed the equator in pursuit of whales, and in 1791 the first American whaler rounded Cape Horn into the untried whaling "grounds" of the Pacific. The many vessels that followed, especially from Nantucket and New Bedford, carried our flag into all parts of the sea and many a Pacific island was first hailed by the daring old masters of these vessels. The whaling industry in New England reached its zenith about 90 to 100 years ago, but with the discovery of kerosene for light, it collapsed almost entirely, though a few vessels have continued to sail from New Bedford almost to the present day, chiefly in pursuit of sperm whales and bowheads, the latter among the floe ice of the Arctic regions.

Now, however, the whalers are few and little remains but the traditions of a once flourishing business.

> Adze and hammer and anvil stroke
>   Echo not from the shore;
> The wharves are old and broken and gray
>   And the whaleships come no more.

Most of us now-a-days have seldom seen a whale either dead or alive, and fewer still can tell the different kinds. All sorts of questions are asked—Is a whale a fish? What is the spout? What kind of whale swallowed Jonah? From the standpoint of a zoologist a whale is not a fish, but a mammal that has become adapted to life altogether in the water. Whales are warm-blooded, bring forth their young alive and suckle them. Within a few years fossil whales of great antiquity have been found in the early Tertiary formations of Egypt that give us certain of the links between the more typical whales and land mammals, and indicate that the group sprang from one of the older stocks of flesh-eating mammals. As a result of their aquatic habits, whales have developed the tail as a swimming organ, have lost their original coat of hair except for a few bristles in some species and have entirely done away with hind legs. The place of a hairy covering is taken by a thick layer of fat or blubber. Nevertheless, from a legal standpoint, it was decided over 100 years ago that in the State of New York a whale is a fish. It seems that in those times the State levied a tax on fish oils brought into its territory. Importers of whale oil, however, refused to pay a tax on this product on the ground that a whale was not a fish, and the law therefore did not apply. The case was tried at length in court, and a decision reached that for the purposes of the law a whale was a fish and its oil was therefore fish oil subject to tax. Whales breath air like other mammals. How then to account for the spout, rising like a jet of steam when the animal comes to the surface? This spout is merely the condensing moisture of the breath, which, expelled with great force, expands rapidly and thereby is momentarily cooled below the temperature of the surrounding air causing the vapor to condense and become visible.

Whales have usually but a single young one at a time, born alive at the surface of the sea. The young whale is about one third the length of the adult at birth and is suckled by the mother for several months.

Whales are readily divided into two chief groups, the first comprising those with teeth, the second those in which the teeth have been lost and from whose palates hang the whalebone plates in two lengthwise series. Of the first group the Sperm Whale is the largest species, but

it is rare in New England waters. The lower jaw only has functional teeth that fit into sockets in the upper lip. Sperm whales feed largely on squid, at times attacking and eating the giant squids, portions of whose huge tentacles are sometimes found as leavings from a Sperm whale's meal.

To this same group of toothed whales belong the various smaller species of dolphins and porpoises, including the so-called blackfish familiar to Cape Cod folk, a species that occurs at times in summer in large schools, which may be driven ashore and stranded.

The second group is called the whalebone whales, and includes six species within our limits. Of these the right whale is the one formerly so much hunted on these coasts, a stout chunky slow-moving whale, attaining a length of some fifty feet, with the upper jaw much bowed upward to accommodate the long whalebone plates which in the middle of the series have a length of about seven feet. The use of the whalebone is to strain out the minute crustaceans and small free swimming mollusks on which the whale feeds. Great masses of water are taken into the whale's mouth and by the closing of the mouth are forced out through the matted hair-like threads at the free ends of these whalebone plates, leaving the food behind to be swallowed. The much larger Arctic whale or bowhead has the upper jaw even more arched than in the right whale to accommodate its 15-foot plates of whalebone. This species is confined to the Arctic Seas. Of the other five whalebone whales on our coasts, one, the humpback, has an enormous fore flipper, equalling about one third of the mammal's length—some 45 feet. This whale is a particularly agile species, often performing many strange antics, thrusting one fin out of the water or lashing its tail violently, again rising almost straight up in the air, to fall over on one side with a resounding splash. The four other large species are long and slender in form, the throat as in the humpback is thrown into lengthwise pleatings or folds which allow of a considerable expansion as the whale opens its mouth to feed. The common finback, attaining a length of 65 feet or more, with a high fin on the lower part of the back, is the one most often seen, for it frequently comes into Massachusetts Bay especially in summer to feed on the shoals of herring or the quantities of small shrimps found near the surface. A similar but smaller species, the northern fin whale, is rare with us but may at once be distinguished by its whalebone, which is black, fraying out into fine white threads. Still a third is the small grampus whale, easily told by the large white bar across the fore limb and by its short pale-yellowish whalebone. Last of all is the great blue whale whose appearance in our waters is not satisfactorily known, though it occurs commonly off Newfoundland and has been cast ashore as far south at least as New Jersey. In this species the whalebone as well as its frayed ends is black. It has been known to reach a length of slightly over 100 feet, the largest living mammal.

All five of these finwhales are quicker in movements than the right whale, so that the larger kinds can not easily be killed with simple harpoons and lances, for so swift are they that they would very soon drag a boat under or overset it. They are killed, however, by means of heavy harpoons with an explosive charge, shot from a gun. The fat of the Blue Whale contains a large percentage of glycerine, used during the war in making explosives.

Concerning the movements and occurrence of the whales mentioned we know relatively little, hence those persons living on the shore who have a chance to see whales might help in the securing of valuable information by sending their observations to the Boston Society of Natural History, taking especial notice,

where possible, of the size, color of whalebone and its frayed ends, the presence of folds on the throat, the number of teeth or other points. The accumulation of such facts may in time be of much scientific importance.

SOME COMMON INSECTS OF THE HOUSEHOLD

By CHARLES W. JOHNSON

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HOUSEHOLD insects is a somewhat popular term given by authors to all insects that may happen to frequent houses. When we realize that as household pests these are unnecessary and that in a well-kept house they are really absent, a much better term would be—insects that sometimes frequent houses. These insects can be divided into three classes: (1) those that actually breed within the house, such as cockroaches, bedbugs, clothes moths and carpet beetles; (2) those that breed outside and are attracted inside by food, including the house-fly, blow-flies, fruit-flies, ants, etc.; and (3) a group of insects that enter houses in the fall only to hibernate, such as the cluster fly and other allied forms.

The presence of those actually breeding in the house is usually the result of carelessness of the housekeeper, or if in an apartment, probably that of a neighbor who leaves dirty dishes and food around promiscuously—this being just the place cockroaches revel in.

You can see the roach a'waving its feelers with delight
When it finds that the jam jar is not closed tight.

A woman in not the most pleasant tone once said "I have no roaches in my house, only water-bugs." Now the water-bug is a little roach (*Blatella germanica*), often called the Croton bug as they became very abundant shortly after the completion of the Croton Water System in New York City in 1842. The Oriental cockroach (*Blatta orientalis*) and the American cockroach (*Periplaneta americana*) do not thrive as well in this latitude as further south, but in some steam-heated buildings they are liable to survive the winter. There is an old saying that it is no disgrace to have certain bugs in the house, the disgrace is in keeping them. A house that is kept thoroughly clean furnishes no suitable environment for these insects. With a thorough cleaning once a week there is also little danger from either clothes moths or carpet beetles.

A very primitive wingless insect that sometimes appears in numbers, especially in dark closed rooms, is the "fish moth" or "silver fish" (*Lepisma*) so called from its peculiar scaly, fish-like form. I much prefer the term bristle-tail, a name that refers to the three caudal bristles. These insects are sometimes destructive to starched clothing, glazed paper and book covers, particularly where starch paste has been used. They avoid light and are very susceptible to the odor of naphthaline, very little of which in a drawer will act as a repellant.

Among the intruders that live outside our houses, the flies are perhaps the most troublesome. There are many species of flies that closely resemble each other, yet in their habits differ greatly. Thus there is much confusion among people regarding the true house fly (*Musca domestica*). Some of these flies are parasitic and useful in destroying injurious insects, e.g., the compsilura fly introduced from Europe to destroy the gypsy moth. Fortunately the para-

sitic species rarely enter houses, thus escaping the notorious "fly swatter." One of the flies that enter houses only to hibernate is the Cluster Fly (*Pollenia rudis*), so named from its habit of gathering in great numbers on the windows. They will often enter in numbers regardless of screens, having crawled in through some small crevice. There appeared in 1922 a European fly *Muscina pascuorum,* larger than the house-fly and bluish black in color. Its habits are similar to those of the cluster-fly and it may prove to be as great a nuisance. The closely allied stable fly (*Muscina stabulans*) though less abundant, so closely resembles the house fly that it is usually mistaken for that species. How can you tell the true house fly, some ask. Well, there is one very good test. If a fly alights on cooked food, nine times out of ten it is a house fly. It is this habit that makes this fly a menace to health. The possibility of its carrying typhoid bacilli is so great that many prefer to call it the "typhoid fly." The name seems somewhat inadequate, as this fly is also liable to carry many other diseases that may be prevalent.

Persons are often greatly alarmed by seeing hundreds of little flies on their windows, fearing that these small flies will grow to be larger ones. This idea seems to be quite general. They forget, if they ever knew, that all flies are first maggots and that all growth is in that stage. When an insect has wings it is full grown, even if no larger than a pinhead. These little flies are fruit or pomace flies (Drosophila) belonging to a different family from the house fly. They are attracted by decaying fruit that has been overlooked and by neglected garbage cans containing refuse fruit in process of fermentation. These little flies, being attracted by the fermented juices of fruit, might be useful in detecting those who are over zealous in making "home brew." All an officer would have to do would be to watch which way the flies go.

Among the country people there is a common expression—"It is going to rain, the flies are biting." This is due to the presence of the cattle fly (*Stomoxys calcitrans*) that so closely resembles the house fly as to be called the "biting house fly." In England it is commonly called the "storm fly." This is not a house fly, but lives in the fields and frequents cattle in large numbers. On the approach of a storm the flies leave the cattle and seek houses for shelter. The blue-bottle flies (Calliphora) and the gray flesh flies (*Sarcophaga*) are usually attracted by meat that should have been put in the refrigerator before becoming so attractive. The green-bottle flies (*Lucilia*) which are often called "fish flies" on account of their preference for fish, are often abundant, but all flies are less numerous than in former years, owing to the enforcement of better sanitary measures.

Ants are another group of insects that are attracted by food, especially sweets. The smaller species usually live in the ground or under stones or boards, but the large carpenter ants (*Camponotus*) deserve more consideration. If they appear in your house you should endeavor to find out just where they have their nest, for they some times desert a hollow tree (their natural home) and take possession of a house and completely riddle the timbers with their galleries. It cost a friend in Brookline over a thousand dollars to repair the damage done by these ants.

There is another insect that often destroys the timbers of buildings known as Termites, commonly called "woodants" or "white ants." These are not true ants, but belong to a much more primitive tribe of insects. In the tropics they are very destructive to all kinds of timber, but this far north where we have but one species, only timber that is near or in contact with the earth is injured. Houses on the seashore where the sand drifts against the woodwork are apt to be attacked by these insects. The pres-

ence of a swarm of the winged form in the late spring or early summer is a good indication that you have in the timbers of your house a thriving colony that demands prompt attention. This swarm of winged individuals have in no way lessened the danger, however, for these do no material damage. It is the large army of workers left behind that really cause the destruction and if these are not promptly removed the results may be like that which happened to a man in Philadelphia. A swarm of the winged form appeared in his parlor and he was warned of the damage that might accrue to the woodwork, but they soon disappeared and he paid no further attention to the matter. Next year another swarm appeared and a short time afterwards I heard that the piano had dropped to the cellar.

There is another group of insects that infest cereals and other dried vegetable products. These are also included among household insects, but are more abundant and troublesome in granaries and warehouses. The meal worm, the larva of a black beetle (*Tenebrio*), is common in feed stores and around stables. Meal is also infected by the Indian meal moth (*Plodia interpunctella*), while the common meal moth (*Pyralis farinalis*) feeds on both meal and grain. Flour is often infested with two or three species of little brown beetles popularly known as flour beetles, while the more recently introduced Mediterranean flour moth has become quite prevalent. Grain is often injured by the grain weevil (*Calandra granaria*) and the rice weevil (*Calandra oryza*). Beans are infested by a particular kind of weevil (*Mylabris obtectus*), and peas by a similar species (*Mylabris pisorum*). One of the most interesting insects belonging to this group is the Angoumois grain moth (*Sitotroga cerealella*). Its close resemblance to the clothes moth is often the cause of alarm among housekeepers. I once visited a friend in Pennsylvania who was very much excited over what she thought were clothes moths. Noting that these were a trifle larger than that species, I said, "Have you any popcorn?" She thought a moment, and then went to a small closet above the kitchen range. On opening the door she was greeted with a swarm of moths. There were only a few ears of corn but the kernels were riddled. It seems surprising that so small a caterpillar could devour so hard a substance.

Where herbs were more generally used in medicine they were often injured by several small beetles. One known as the drug store beetle (*Sitodrepa panicea*) is still prevalent, feeding on all kinds of dried substances. Another that feeds largely on tobacco, ruining cigars and cigarettes, has become popularly known as the cigarette beetle (*Lasioderma serricorne*). This is not as common as the drug store beetle, probably because the smokers do not give it a show. I was describing this little beetle to a friend who was no lover of the cigarette and he said: "I call that a beneficial insect. It should be encouraged." Evidently there is a difference of opinion as to what is an injurious and what a beneficial insect. Little beetles known as spider beetles (*Ptinus fur*) also feed on various dried materials. In November 1920 a party brought me one of the spider beetles (*Niptus hololeucus*) which he was finding in considerable numbers in his house, especially in the bathroom. Their presence in the bathroom could be explained by the fact that the steam heat had made the rest of the house too dry for their comfort, while the bathroom presented more humid conditions. The presence in Boston of this European beetle which had only been recorded in this country from a house in Montreal was difficult to explain. That there was something in the house on which these beetles had fed, was evident, but a thorough search

by the owner revealed no object that was infected. The following November they again appeared in lesser numbers and then practically disappeared.

In referring to the various insects I have not dwelt on insecticides for it seems unnecessary. No doubt many of the insect powders, are good of their kind but you must do your part. When people say, "We have tried everything and still they are there," all I can say is, Have you thoroughly cleaned your premises? If they say yes, well, I hae ma doots!

FOSSILS—WHAT THEY ARE AND THEIR USES TO MAN

By Dr. J. A. CUSHMAN
SHARON, MASSACHUSETTS

You probably think that a fossil is one of the most useless things in the world. How often have you heard a person spoken of as "an old fossil." It isn't complimentary, but to give the idea that the person is behind the times and not interested in up to date things.

Fossils are remains of either animals or plants that have lived in the past, and left traces in the rocks. If you go into the Museum of the Boston Society of Natural History, you will find there some large slabs of red sandstone. These came from the Connecticut Valley and are millions of years old. Once they were wet sands. On these slabs may be seen footprints of animals that walked across the muddy sand while it was still soft. You can measure the length of step from one footprint to another. Some of the animals were large, and across the same slab are the tracks of much smaller ones. There are also fine markings where worms or crabs crawled across the mud, and perhaps the larger animals were after these. Then a shower came up, and you can see the marks of the raindrops. One side of the raindrop marks is deeper than the other, showing which way the wind was blowing at that time. So you see, from this slab of rock, you can with your study and imagination tell many things that took place in that far away time. It is really a record written on the slab of rock that one who is trained in the language can read.

Fossils have been preserved in many strange ways. You all have seen amber beads. Amber is the gum or pitch from trees that lived long ago. It has been preserved all this time. In those days, insects of strange kinds crawled up the tree trunks and became stuck in the gum. More gum oozed out and covered them. So in some amber there are preserved these insects of older times with all the perfect details of their delicate wings.

In California there are pits where asphalt-like material is dug out. It is now hard, but thousands of years ago it was soft and sticky. Different kinds of animals got into these sticky pools and died, leaving their bones in great numbers. Thousands of these bones have been gathered, and as a result, we know a great deal of the animals that roamed about in that part of the world many thousands of years ago.

You have all seen shells along the beaches and have seen how easily they are buried in the sand. This same thing has been going on along the shores of the oceans for millions of years. Later, these deposits may have been raised far above sea level, and these sea shells are then found high up above the present level of the ocean. Such rising and fall-

ing of the land and sea level has been slowly taking place as far back as we have any record in the rocks of which the earth is made.

But you may be saying, "Of what real use are these to man at the present time? It may be interesting to know about the queer animals of the past, but how does that really help us today?"

You may not at first believe it, but most of our modern life, especially city life, depends upon these fossils of the distant past. Due to fossils, you heat your home and school buildings, have electricity with all that means in your every-day life, run automobiles and trucks and trains, have the thousands of varied colors in dress goods, asphalt streets, and so on and on. Do I hear you say that these things come from coal and oil and other things that are not fossils? Then let us see. What is coal? It is the remains of fossil plants that lived far back in the Carboniferous period, an early stage in our world history. In the coal, and especially in the slate above and below the coal beds, are the remains of trunks of tree ferns and their leaves. The coal beds are the result of fossil plants. Then all the varied uses of coal that you can think of depend upon fossil plants. Gas is made from coal, so if your dinner is cooked on a gas stove, you are again using fossils indirectly. You have heard of coal tar products, and of aniline dyes, again coal fossils. Many medicines and such things as vaseline and different kinds of wax are obtained in the same way. Even perfumes and flavorings can be made from this same source. You can see how dependent you are upon these fossil plants.

It is often said that this is the age of gasoline. Here again, gasoline is made from crude oil which is taken from deep down in the earth where it has accumulated for a long time. The oil is made from fossil plants and animals that lived a very long time ago. Think of all the uses of gasoline, naptha and kerosene, and see what you owe to these great numbers of tiny animals and plants that lived so long ago. There are hundreds of products that are made from crude oil, and hundreds more will be produced just as soon as a use is found for them.

Fossils can be used to help find oil. Each different layer of sand and clay, sandstone or limestone of which the rocks of the earth are made have usually fossils in them. By long and careful study it has been found that the fossils in each different layer differ from those of other layers. They also have the same differences over wide distances. So if a sample of limestone or shale is given to a trained worker, he can tell from which layer in that region it came. Now, if it is known that oil occurs in a certain sand the position of which is known in the section of the earth, it is possible to predict how deep that sand is below a given place by a study of the fossils near the surface. It is as if you knew that John Smith, the grocer, had his store on the second floor, and Tom Jones, a shoe dealer, on the sixth floor. So when you find the sign of John Smith, and the elevator is not running, you know you have four more flights of stairs to climb to reach Mr. Jones, the shoe dealer. So if the oil layer represents the second floor and we find the fossils that show we are on the sixth floor, it means going down four imaginary flights of stairs to get to the oil layer.

Many limestones are made almost entirely of the shells of fossil animals that were buried in the muds of the ocean in past ages. These become cemented together and hardened. Then they are raised far above the sea as mountains are built. If they have been heated and pressed enough in this process, the limestones are turned into marble. So the beautiful monuments and buildings may owe their beauty of form and color also to fossils.

The chalk you use in school, if looked at under the microscope, will be found to contain the shells of tiny fossil animals. The phosphate beds of the Southern States, which are dug out to help make fertilizer, are made up largely of the bones of fossil animals.

If I should ask you to name the largest things ever built by man, probably you would say, "The Great Pyramids." They are undoubtedly the greatest in size at least, and have been looked up to for thousands of years with wonder that man, who is himself so small, could have built these mighty structures. The greater wonder is that he could have done it without the modern machinery we have to-day. Yet hundreds of thousands or millions of years before, other builders were at work getting the material for the pyramids ready for man. They were some of the simplest and lowest forms of animals that we know anything about. They lived in great numbers in the warm seas in that far away time, and their shells by uncounted millions built up the thick limestones. Later, these were raised above sea level in the hills along the Nile, where the workmen of an Egyptian Pharaoh cut them out and built the pyramids. So the mightiest monuments man has ever built are made of limestone built up of fossils of some of the smallest animals that we know anything about.

Perhaps this will be enough to show you that a fossil is not to be looked upon as something that has lost its usefulness, but may after all have been only getting ready for real use.

THE PRESERVATION OF SCENIC BEAUTY IN TOWN AND COUNTRY[1]

By VAUGHAN CORNISH, D.Sc.

SCENERY, the outdoor view, is the aspect of the world which all men have in common. Its true beauties, the aspects more than pleasing which fill the mind with joy, result from combinations which produce mutual enhancement of the parts, harmonies in the full sense of the word.

The scenery of a country is artificially modified from generation to generation, and it is necessary therefore that we of the academic world should discover and define the combinations which result in scenic beauty if we are to take the responsibility of advising on measures for its preservation. We have, in fact, to lay sure foundations for an esthetic of scenery.

Great Britain's heritage in scenery is of town and suburb, village and farm, wild waste places and the splendid setting of the sea, all under the canopy of soft skies given by oceanic climate.

SCENIC HARMONIES OF THE TOWN

The characteristic beauty of the street is the effect of a vista, the pleasant path by which the eye follows converging lines to a point of rest in the far distance. Piecemeal reconstruction of streets is necessary in a progressive era, and, in order to preserve the dignity of the street, uniformity of cornice lines must be enforced by municipal authority; otherwise the vista vanishes, camouflaged by vertical strips.

The necessary increase in height of houses is reasonably lamented when disproportionate to width of thoroughfare, but the erection of lines of lofty buildings facing great open spaces is free from this drawback. The beginning of the epoch of steel-framed sky-scrapers has, it is true, the inevitable disadvantage of rearing isolated blocks which cut the sky harshly with square quoins, but as the type of building becomes more general these blocks unite in a long façade more imposing than any vertical plane in scenery except the cliff which rises sheer from the waters of the ocean.

Hearing that lofty steel-frame building had begun in Park Lane, I went to see the effect. In Victorian days I spent so many pleasant and idle hours on the shady lawns of Hyde Park between the Achilles statue and Grosvenor Gate that I grew fond of the irregular line of miscellaneous architecture seen through the plane trees and beyond the border of brilliant flowers. The new building dwarfs them all, and by breaking a pattern blurs the pleasant members woven into a view of which the pattern was a part. But this drawback was amply compensated by a new element of nobility in the scene, that of imposing loftiness, which was most felt when the new building was viewed through the bare boughs of the plane trees. I found also another improvement, for when looking across the open park with its spacious sky the presence of a lofty façade gave what was wanted to complete an opulent impression of general amplitude. I returned to the spot a few months later when the lattice of the boughs was improved by the perforated screen of half-opened leaves, and the satisfactory impression of the first visit was not only confirmed but strengthened. Yet what is happening

[1] Address of the President of the Conference of Delegates of Corresponding Societies, at the meeting of the British Association for the Advancement of Science, Glasgow, September, 1928.

makes many people shudder and prompts gloomy comment on the commercialism of the age. If Park Lane were destined to remain as it is at the present moment I would not undertake to say that the break in the pattern was pictorially justified, but I am visualizing the pattern as it will be when complete. Hyde Park will then be glorified by a long and lofty façade, as a spacious plain is more glorious if bounded by a range of mountains than a line of hills. Meanwhile the individual buildings will gain in the details of their structure as the artists gain greater mastery of the new medium.

In the great cities there are lofty outlook stations accessible only with much labor, as at the Monument and St. Paul's in London. In Edinburgh and elsewhere an Outlook Tower has been built through the prescience of Mr. Patrick Geddes. In the lifts which are necessarily installed in lofty steel-frame buildings, municipalities have ready to their hand a means of providing the public with easy access to outlook points selected for the beauty of their prospect.

The city skyline of spire and pinnacle is never more imposing than in misty air, which emphasizes outline as much as it diminishes relief, and the ruddy tinge of sunshine struggling through a pall of smoke confers excitement of color which counteracts the dulling effect of lessened light. But in our climate there will never be lack of misty days, and, even apart from considerations of health, we pay too dearly for the fine, lurid effect of smoke. The black coat on buildings obscures the shadowing to which cornice and colonnade owe much of their beauty. The growth of vegetation is so checked as greatly to impair the contribution of blossom, foliage and tracery of boughs which is desirable not only for its own beauty but as a foil to the insistent forms of architecture, multiplied in cities beyond the endurance and capacity of the eye. The effect of smoke is equally adverse to the social scenery of our cities, for, by screening the warmth, the brightness and the vitalizing rays of the sun, inducing fog and smirching every garment of fine texture and bright color, it militates against the habit of *al fresco* meals and social intercourse out of doors during hours of rest which adds so much to the scenery of cities in warm and sunny lands. When the pall of smoke is removed it will be found that the paving and surface draining of towns has lessened the drawback of our natural climate for sedentary outdoor recreation, which is mainly that of exhalation from damp ground. Moreover, the better growth of vegetation will bring something of country fragrance to the air of towns, the fragrance which has so strong an influence upon our esthetic mood and power of appreciating beauty.

The preservation of scenic harmony is never more difficult than where new construction has to be undertaken among venerable buildings. Yet such problems can be solved, as I learned when I lately went to Winchester to revive the memory of ancient beauties which I had not seen for thirty years. It was a perfect day in early spring, and Cathedral Close and College Precinct were seen in all their mellow charm. Noticing a new building in College Meads I turned aside and found myself within a cloister erected as the war memorial of Wykhamists. Here I felt the spirit of the past and saw an added glory to Winchester. There was neither lifeless imitation of traditional forms nor architecture so alien as to introduce incongruity. The roof of rough stone, suited to its exposure and pleasantly breaking up the sunlight, the good smooth stone and reposeful circle of the arches, the splendid message of the inscription to the dead which circles the knapped-flint walls of the cloister in letters of white stone shaped to the old Lombard script, are the satisfying out-

come of that cooperation between an artist and a scholar which should always be sought for construction in such sites. Moreover, the hand of the careful craftsman can be seen, the final satisfaction of the nearer view of architecture.

Scenic Harmonies of Suburbs and Seaside Resorts

Ever since our towns grew large, the city man longing for the sweet fresh air of the fields and the scenery of vegetation has sought a home in the situation bordering both the country and the town, but no sooner was he settled than the locus of these advantages shifted further out. By fixing a rural ring round the city and building compact suburbs beyond, the selection of a home permanently suitable for the average business man would be made possible for the first time since the beginning of the industrial epoch.

The present suburbs are often preeminent in garden decoration, especially in the tree blossom and flowering shrubs displayed to the road, but the scenery of social life is impoverished by radial building. The straggling suburb is inferior to the town in illustration of collective life and inferior to the country in illustration of the round of individual occupation. The detached suburb of compact plan, by providing better illustration of both individual and collective occupation, would remove the common reproach that suburban scenery is uninteresting. Moreover, we can plan its residential roads so as to combine excellencies which in Great Britain have hitherto been separately associated with the college, the mansion, the cottage and the villa. The plan to which I refer is well established on the other side of the Atlantic, where the admirable example of Toronto is fresh in the minds of many members of the British Association. The front gardens are not fenced from one another, and in consequence the detached villas stand in the dignified sociability of collegiate architecture. The avenue of shady trees by which the citizen goes forth to his work in the morning and returns at eventide is stately as the approach to a lordly country mansion. The front gardens with their flowers for all to see have the friendly brightness which is the charm of the English cottage garden open to the road, whilst the gardens at the back of the houses, adequately fenced from one another, give the privacy which is a cherished character of English villadom.

The large parks and heath lands now being replanned, sometimes with a central golf course, are free both from the bane of nineteenth-century building and from the pressure to conform to an earlier tradition. Here adaptations of a Mediterranean type of architecture, harmonizing with the landscape, are already to be seen. These embody the upper loggia and other facilities for shelter combined with open-air life. It can not be too clearly realized that this return to nature is an advance upon any of the earlier architecture of England.

The sea coast is our chief health resort, both for the annual holiday from business and for the restful years of retirement, and sometimes a suburb also for the city man. Half smothered in the modern growth of the seaside resort are the cottages of the old fishing village which was rightly placed to hug the shore. Here and there on our coast can still be found an untouched fishing village in a cove beneath the protecting cliff which preserves an unspoiled scene of the adaptation of occupation to environment. The general practice of developing the seaside resort on similar lines, with building front close to the beach, is however radically wrong. The building-line should be placed at the back of a broad lea, for a mere roadway and footpath between the houses and the beach is utterly inadequate as seaside pleasaunce for a considerable town, and the mind can with difficulty

receive the message of the free and open ocean amidst a jostling crowd. Fortunately, the more spacious planning is a counsel of economy as well as amenity, for the need for erecting costly sea defences is postponed, and meanwhile the growing population becomes better able to bear the financial burden.

Scenic Harmonies of Farm and Village

The country parishes of the English lowland have a decorative character unsurpassed in quiet charm. The land undulates, rivers flow quietly in gracious curves, there is wealth of broad-leaved trees of rounded form, and the fields are divided by bushy hedges where the natural vegetation is preserved. The preference displayed by cultured Englishmen during the eighteenth century for the scenery of prosperous agriculture was due in part to a shrinking from sterner aspects, but we have only to imagine the countryside as it was on the eve of nineteenth-century building (hurried, haphazard and largely in staring brick and poor slate) to realize that rural England of the eighteenth century would have held us enchanted by the perfection of its repose. House building since the great war has been even more rapid than in the nineteenth century. It is, as Sir John Russell remarked at a meeting of this conference, of a curiously mixed kind. The best houses are excellent in form, tone and color, and take their place in the landscape more quietly than the late-Victorian villa. The worst hold the eye against its will by harsh form and staring color, and, in many cases, by the conspicuousness of a site chosen for the sake of a wide prospect. While deploring such philistinism let us not forget that the Englishman's fondness for trees and love of privacy will largely remedy the present state of things. Experience tells us that in twenty years the little bungalow will be almost hidden in a grove, even though the view from the windows be partly screened.

In the great avenues of a well-planned city we have the stately effect of the vista, in many English hamlets and village streets the subtle charm of grouping which conforms spontaneously to the winding course of the valley's waterway, as beneath the Berkshire downs, on the Cotswolds and in the coombs of Devon. The preservation of this picturesque inheritance is fortunately made easier by the revenue derived from the motor industry which provides funds for the by-pass required for acceleration of traffic.

The winding country lane with overarching trees has long been a cherished possession of English scenery, in summer a corridor of cool green shade, in autumn an avenue of golden light, but we have never had Napoleonic roads bordered by league-long avenues and, as Professor Patrick Abercrombie has pointed out, the requirements of motor traffic provide the occasion for introducing this new element of beauty.

In the eighteenth century the traveler crossing England passed through a string of villages and large and small towns. Railways were, however, laid out so as to avoid villages and many of the smaller towns, so that the traveler of the nineteenth century rolled peacefully through mile after mile of verdant fields. The motorist of the twentieth century returning to the main roads receives a very different impression of the countryside, and consequently overestimates the recent encroachment on rural England.

If we leave the main motoring roads and also reject the cheapened charms of certain spectacular features of scenery, we find large blocks of agricultural England in which scenery is unaffected by recent occurrences. I lately visited a line of twelve country parishes lying on the slope of the West Berkshire downs overlooking the Vale of White Horse, places which I knew intimately

five-and-thirty years ago and had not seen since. There was no perceptible change in the lay-out of the fields, in the operations of agriculture, or in the architectural appearance of the villages. The light car had replaced the dog-cart upon the roads, otherwise all objects were as a generation since. One attribute of rusticity was, however, impaired, that of seclusion; the price paid for the rapidity and ease of access by car.

I have also gone back, after the lapse of more than forty years, to the village of Debenham in East Suffolk, where I was born and bred. Windmills have fallen into disuse and fewer handicrafts are carried on in the village street, but, throughout the thirteen-mile drive from the railway station, architecture and agriculture presented the same appearance as of old, even to the distinctive chestnut color of the cart horses and the manner of their harnessing to the plough. Visiting the school at Debenham, I found no apparent change of type. The true-blue eyes characteristic of the East Anglian stock preponderated as much as among the children of two generations back whom I knew in my boyish days. As I watched the school disperse, I felt that the charm of the high street was due as much to the blithe movements of happy children as to the statical background of old gabled houses.

The Needful Background of Wild Nature

Urban and agricultural scenery, though utterly unlike in decorative character, have the common element of human effort and contrivance. The scenery of wild nature from which this element is absent is not always more decorative than that of cultivated land. The landscape which is, perhaps, most satisfying for residence is that in which civilization is seen with ample background of the wild. But in many English counties there is no such background, for cultivation covers hill and dale. Therefore, as we can not everywhere view the wild, it is the more important to preserve such complete landscapes of untouched nature as we still possess, refuges where we can steep ourselves in the aspect of spontaneity with no reminder of man or his works. Nature and mankind are twin sources of inspiration, but the intimate and moving scenes of human life are not for the most part comprised in the outdoor view and do not therefore form part of the scenery of farm and city. Nature, on the other hand, though many of its wonders are microscopic, is most inspiring in the general view, and it is necessary for full development of the personality of a nation that the scenery accessible to the people should comprise the untouched elemental prospects which are unrivalled in their power to impart a reverent conception of the universe.

Of all the greater manufacturing countries with dense population, none equals our own in accessibility of coast and proportion of coast line to area. The sea shore provides a purely elemental prospect, the panorama of sea and sky with its unmatched horizon and never failing harmony of tone and color. The cliff by the sea presents from its precipitous verge an outlook unsurpassed even by Alpine scenery. Here from our island home we gaze upon a scene untouched by time, an image of infinity and eternity unequalled in its potential influence upon the loftier imaginings of our people. But although the view from the cliff can not be impaired, access to the view is often denied, and I submit that the time has come when no new enclosure extending to the cliff should be permitted and no further restriction of access allowed.

Education in Scenery

It is the duty of the academic world to educate the nation in the appreciation of its heritage of scenery. When

the benefits of scenic beauty are thus extended from the few to the many, the people themselves will guard the goodly heritage. The best method for carrying out this instruction in school is in connection with regional survey. The scenery of the home region has a more than local character, for it is almost an epitome of the scenery of the world, comprising the round of day and night, the response of vegetation to the seasons, forms of cloud common to all countries, the rising and setting of the sun and the revolution of the changeless constellations. Moreover, scenery appeals to the mind as a whole, for everything that we know about an object affects the way in which it appears to the eye, yet the feeling imparted by appearance is not limited by the bounds of knowledge. If the teacher will concentrate upon the perfection of characterization which brings the understanding of the heart, response among pupils will be widespread, for the esthetic faculty is latent in the generality, not, as the creative power of artistry, an exceptional endowment. Neither do the cares of poverty prevent the mind from dwelling on scenic beauty, as all who have traveled in Japan are well aware. There the coolie, whose standard of living is far below that of our working class, goes on pilgrimage to see each culminating beauty of the seasons, for the birthday of a favorite flower is a religious festival throughout the land. At the back of this are centuries of education in esthetic perception.

Those of us who aspire to be instructors in scenic beauty must submit to a certain discipline in order to acquire mastery of the subject. In our walks abroad we must let busy thought quiet down, that the mood of receptive attention may have full play. Then the whole being can be stirred, for the emotions aroused by scenic harmonies are far from being merely primitive; they result not only from inheritance but from the sum of all the past feeling, thought and action of a man's own life. It is only the jostling, obtrusive thought of the hour which is eliminated in the contemplative mood. To all who attain this receptive habit, the harmonies of scenery bring an integration of the personality which is beyond the reach of those who neglect the correlation and synthesis of thought and feeling.

The Necessity of Measures for Protecting Scenery

Our special function in regard to preservation of scenic beauty is research and education, but both processes require time, and the enemy, ugliness, must be held by a frontal force while we get round the flank. It is universally admitted that there are parts of the country where irreparable damage to scenery is needlessly threatened, and it therefore appears desirable that the British Association for the Advancement of Science should urge His Majesty's government to stimulate the employment by local authorities of the powers already conferred upon them by Parliament for the preservation of scenic amenity in town and country.

SURVEY OF THE LIFE OF LOUIS AGASSIZ
THE CENTENARY OF THE GLACIAL THEORY

PREPARED UNDER THE DIRECTION OF DR. HENRY FAIRFIELD OSBORN

By HELEN ANN WARREN

ASSISTANT IN THE OSBORN RESEARCH ROOM, AMERICAN MUSEUM OF NATURAL HISTORY

Louis Agassiz arrived in America one year before the founding of the American Association for the Advancement of Science in September, 1847. He took a very active interest in the Association, served on its standing committee, attended meetings and contributed papers and addresses. He was also one of the founders of the National Academy of Sciences in March, 1863. A review of his life at the present time is of especial interest because of the centenary of the Glacial Age theory, which was developed between the years 1815 and 1837 by Charpentier and Agassiz and will constitute a prominent subject of the coming eighty-fifth meeting of the American Association for the Advancement of Science, to be held in New York, December 27, 1928, to January 2, 1929. The extraordinary difficulties encountered and surmounted by Agassiz in getting his start in science furnish also a splendid example to the highly pampered university youth of the present day.—HENRY FAIRFIELD OSBORN, *president of the American Association for the Advancement of Science.*

DURING the sixteenth century science was still an avocation of the man of wealth and leisure who could afford to dabble in peculiar phenomena, and of the man with an inborn love of puzzling out the secrets of nature, who was fortunate enough to interest some rich patron or publisher in his investigations. Physics and chemistry, astronomy, mathematics and medicine enjoyed a restricted vogue; the natural sciences, zoology, botany, geology and mineralogy, were less considered. Aristotle had supposedly defined their scope once for all and, though occasional men like Leonardo da Vinci were interested in the animal and vegetable life amid which they lived, most men dismissed it from their speculations.

The discovery of America insensibly changed this attitude. Here were adventure, romance, fabulous wealth, strange beasts. Men eagerly sought for details of this Eldorado, and tales spread from learned men and courtiers to the illiterate laborers swapping stories in country inns. Shakespeare, painting the passing show in England, remarked in "The Tempest:"[1]

> Were I but in England now, (as once I was), and had but this fish painted, not a holiday fool there but would give a piece of silver; there would this monster make a man; when they will not give a doit to relieve a lame beggar, they will lay out ten to see a dead Indian.

The first to bring tidings of the New World were Spaniards, following close upon the heels of Christopher Columbus. There was Don Gonzalo Fernandez de Ovieda y Valdes, Spanish Governor of San Domingo in 1517; and the Peruvian missionary, Reverend Joseph d'Acosta, S. J., who was the first white man to discover fossil bones in South America, though he did not recognize their importance to paleontology. There was Francesco Hernandez, a Spanish physician sent to Mexico by King Philip II to report on plants, animals, minerals and men; and Bernal Diaz del Castillo, companion of Cortez, astonished at the marvelous botanical and zoological gardens of Montezuma's splendid courts at Chapultepec; and there was Garcilassa de la Vega, son of a Spanish Governor of Peru and a princess of the royal Inca blood, whose traditional ancestors were Manca Capac and the Sun. This

[1] Written in the year 1611. The island of Bermuda was discovered in 1593 by Henry May, who was shipwrecked there and probably the exploration of those islands gave Shakespeare his setting.

royal half-breed was the first native of the American continents to write of his country and in his "Royal Commentaries of Peru," produced a valuable book, remarkable, like those of many of the early commentators on America, for its freedom from marvel-seeking.

The French were destined to explore the vast western prairies and plains of North America, sending Longueil in 1759 to discover the Big Bone Lick of Kentucky while navigating the Ohio River; to produce Cuvier, who with Buffon was the well-spring of American as well as European natural science when the nineteenth century had just dawned; and to inspire great teachers like Lamarck, Lesson, Audubon and Rafinesque. France had an early interpreter of the Americas in Jean de Lery, a Huguenot missionary to Rio de Janeiro in 1595, but almost two centuries elapsed before the French became the spokesmen of the New World. This interval was occupied by careful English observers in our Eastern States; men like Thomas Harriet, a protegé of Sir Walter Raleigh's; Captain John Smith, of Virginia; and Governor John Winthrop, William Wood and Thomas Morton, of New England. The Dutch, Germans and Swiss played no part as chroniclers of these early explorations.

Two centuries passed, and the little Swiss canton of Neufchâtel took a leading part in American development by yielding to Princeton University Arnold Guyot, comrade of Agassiz in glacial investigation; to our national Geological Survey, Leo Lesquereux, the interpreter of the flora of our vast coal beds; and to all America, Louis Agassiz, glaciologist, zoologist and primarily teacher, whose contagious enthusiasm, profound knowledge and skilful instruction made scientific pursuits dignified, fashionable and valuable in the eyes of the American people.

Agassiz arrived in Massachusetts in 1846, a European scholar of recognized ability and intellectual daring whose reputation rested upon monumental researches into the science of living and fossil fishes and upon his new and, at the time, incredible theory of a glacial age. Science was not a serious vocation for American men, engaged in the business of building up a country. Europe was the center of learning and the mecca of scientific students, as it is to-day of artists and musicians. Tradition and authority rested with the European masters, and Agassiz came with the luster of his tutelage under Cuvier, the brilliant founder of paleontology, and under Baron Humboldt, who had succeeded to the place once occupied by George Leclerc Comte de Buffon, as the dean of scientific men in all Europe. To these great masters he added familiarity with the British geologists of contemporary fame, Buckland, Murchison, Sedgwick and Lyell. He came as a professor, lecturing before the Lowell Institute, and remained as a citizen whose enthusiastic welcome by American institutions was reciprocated by his enthusiasm for American institutions. Having been forced by poverty to copy his reference books, when access to the originals was difficult, and having known the hardships, even hunger, which beset any but the wealthy who sought an education in the Swiss, German and French universities, Agassiz was impressed by the free schools and public libraries of the Commonwealth of Massachusetts. He saw in them his opportunity to teach thousands and he embraced it.

Agassiz's school education had been a nine-hour daily drilling in languages, the classics and arithmetic, overshadowed by the fact that his father's slender clerical income must provide for other children beside himself, and by the grave possibility that unless he showed unusual promise he must at the age of fourteen give up the lessons he loved and go to work for his uncle, who was a merchant. It had given him the moral

force and courage essential for his scientific career which virtually began when he won his parents' permission to enter the little Academy of Lausanne, just before his fourteenth birthday. He entered the academy with an expressed desire to "advance in the sciences" and a plan mapped out in his mind of study at the University of Neufchâtel, to be followed by four years at a German university and to be crowned by work in Paris. This ambitious program worked out surprisingly well.

At Lausanne, Louis received his first lessons in zoology and spent his spare time in the woods and fields, or swimming and fishing in the lake. His desire to "see for myself where the truth is" grew strong and convinced his uncle, Dr. Mathias Mayor, who was a prominent physician of Lausanne, that Louis had a great natural bent for the study of anatomy and, therefore, of medicine. Dr. Mayor persuaded the boy's parents to this view and in 1824 Louis, who was then seventeen, entered the medical school at Zürich. His younger brother, Auguste, remained with him and together the boys copied in longhand books they were too poor to buy—among these was Lamarck's "Animaux sans Vertebres," which was of little interest to the younger brother, yet he faithfully wrote it out for Louis.

In 1826 Auguste entered his uncle's business at Neufchâtel, and Louis went to the University of Heidelberg, to unexpectedly become an author before he had become a doctor of either philosophy or medicine. He arrived at the university with glowing letters from his professors at Zürich, which, with his native charm and apparent determination to work, soon won him recognition. An interested professor suggested that he make the acquaintance of a fellow-student, Alexander Braun, who was as interested in botany as Agassiz was in zoology; thus Agassiz formed one of the greatest friendships of his life and was led into making a momentous change in his university. The boys were constantly together, studying, talking, taking long walks into the country. It being too far for Louis to spend his vacations at home, Braun invited him to his father's house at Carlsruhe where they were encouraged to examine Herr Braun's fine collection of minerals and to pursue their own investigations. In 1827 Agassiz fell ill of typhus fever and the anxious Brauns cared for him at Carlsruhe, Alexander accompanying him to the Agassiz home at Orbe for his convalescence. In October of that year, Braun, whose interest in botany was to bring him distinction in the directorship of the Berlin Botanical Gardens, wrote Agassiz that he considered the University of Munich a better place than Heidelberg for the development of their scientific knowledge. Among the inducements were free lectures, lodgings as cheap as those at Heidelberg, a theater open to students for a very small fee, and the association of such men as Oken,[2] Schubert and Fuchs, as well as a rich museum for study and comparison. Agassiz thought well of the suggestion and the two set out on foot for Munich, followed very shortly by Karl Schimper, one of their firm friends. It was at Munich that Agassiz unexpectedly became an author at the age of twenty-one.

While still keeping up his medical studies out of deference to his father's wishes, he had become more and more enthralled by the natural sciences and in Munich were Martius, Oken, Döllinger and Schelling, men who could teach the eager young man and who were quick to recognize his worth. C. F. P. Von Martius was at that time engaged in publishing his great work on "The Natural History of Brazil," which he and J. P. Spix had investigated in 1819 and 1820 while touring the country on horseback, in sailboat and canoe. Spix

2 Transcendental anatomist, author of *Philosophie der Natur.*

undertook the zoological portion of the work, but in 1826 he became ill and died, leaving the description of the fresh-water fish untouched. Martius engaged the nineteen-year-old Agassiz for this task and was well repaid for his belief in the young Swiss, whose doctorate of philosophy predated his first publication just long enough to appear beside his name on the title page of the first edition, in 1829. Agassiz had characterized nine genera, embracing forty-two species new to science. The first copy of the "Brazilian Fishes" went to Cuvier, and Agassiz received a long and gratifying letter in reply. In fact, he was so heartened that he began the composition of his monograph on "The Fresh Water Fishes of Central Europe," for which he had first collected material in the Lake of Morat. He employed an artist, Joseph Dinkel, and secured magnificent illustrations which repaid him for his personal discomfort while eking out a living for himself and Dinkel from his very meager funds. In 1830 he succeeded in interesting a publisher named Cotta, of Stuttgart, in the materials thus far accumulated and secured 20,000 Swiss francs for the work, which appeared subsequently between the years 1839 and 1842.

In 1830 also, when twenty-two years old, Agassiz was awarded the degree of doctor of medicine, with honors, from the University of Munich and proceeded toward Concise to set himself up in medical practice. On the way home he stopped at Vienna to study the fossil ichthyology toward which his investigations of the living forms had directed his attention. Arrived home, however, he seemed to settle down to becoming a practicing physician; this quiescence lasting little more than a year. In December, 1831, Agassiz set out for Paris, finally fulfilling his boyish plans of study through his uncle's generosity, and still but twenty-four years old. He took a small room near the Jardin des Plantes and went on his very first day in Paris to call upon Cuvier. He was warmly received and so won the master's respect and trust that Cuvier turned over material he had collected for a monograph on fossil fishes, which was later incorporated in Agassiz's "Recherches sur les Poissons Fossiles," the appearance of which in 1833 won Agassiz at the age of twenty-six the coveted Wollaston medal of the Geological Society of London. Cuvier did not witness his young friend's triumph; in 1832, only a few months after their first meeting, he had died, leaving Agassiz a well-stocked memory of his views and the admonition "Work kills." Of this maxim the robust Agassiz remained heedless.

The publication of the "Poissons Fossiles" in five volumes illustrated throughout by Joseph Dinkel had been no easy task. After months of a tormenting struggle to make ends meet, Agassiz had finally interested Baron von Humboldt in the work and had thus secured publication funds and the benefit of the Baron's extensive and influential connections. Von Humboldt developed a decided liking for the Swiss student and so in 1832 the chair of natural history at Neufchâtel University was secured for a poor physician who had been wavering on the brink of return to his country practice.

Discovery of the Glacial Age

In 1832 Louis Agassiz was a tall, healthy young professor just starting upon his career at Neufchâtel and planning the formation of a natural science society which took form in December of that year with interesting results, because before this body Agassiz first promulgated, in the year 1837, his theory of a Glacial or Ice Age. Twenty-two years of previous observation by Venetz and Charpentier led up to this great generalization.

In 1815 M. Charpentier, the director of the salt works at Bex and a distin-

guished geologist, had passed a night at a mountaineer's hut in the hamlet of Lourtier and had been told by his host that huge boulders of Alpine granite were frequently found perched on the sides of valleys where they could only have been left by ice. Charpentier became interested in the theory and spent the succeeding twenty years in accumulating evidence that Switzerland had once been covered by a sheet of ice. Agassiz at that time was absorbed in studying fish, living and fossil, and in 1828 his intense observation of the Brazilian fish and the fossil forms of European waters led him into geology through the backdoor of paleontology. In 1834 Charpentier published his conclusions; Agassiz was interested but unconvinced; he visited Charpentier and surveyed the land for himself, becoming more and more enthusiastic about the evidences of the "Ice Age," and in 1837 he boldly declared his belief, that before the elevation of the Alps a sheet of ice had covered Europe from the North Pole to the Mediterrean sea. He was considered mad. The French, German and Swiss scientists, even in his immediate group, laughed him down and were echoed by his English friends of recent acquirement—Buckland, Sedgwick, Murchison and Lyell. However, one by one, they bowed to Agassiz's careful study of the Aar glacier from the Hôtel des Neufchâtelois, which he and his friends, Guyot and Desor, constructed of logs on the living glacier; his calculation of the speed of a glacier's advance; his perilous descent into its heart and consequent knowledge of its actual construction; his examination of the grinding effect of ice upon rocks; his ascent of the hazardous Jungfrau and Matterhorn. Scotland, England and Ireland gave further mute testimony in support of Agassiz and later North America and finally South America bore him out. The scientists capitulated and the glacial age or ages now occupies fifth grade geography books. "It is a matter of the greatest importance to know," wrote Agassiz in 1837, "if toward the Poles and generally wherever erratic boulders exist, the rock surface that carries them is polished as in the Jura." It took a long time measured in a lifetime for him to find out, as Jules Marcou has described from his own memories of the event for the editor of *The Nation:*

> The city of Neufchâtel has just celebrated the fiftieth anniversary of the foundation of its Natural History Society. On the sixth of December, 1832, under the leadership of L. Agassiz, a small group of six scientific men met to found this society. Agassiz was then only twenty-five years old. He came from Paris, where he had studied with Cuvier and Humboldt, and the small city of Neufchâtel, which had then scarcely 6,000 inhabitants, by a rare good fortune which does the greatest credit to the liberality and wisdom of its citizens, acquired this young naturalist, full of enthusiasm, of learning far beyond his years, and of a prodigious activity for work for the propagation of science such as few people are gifted with. . .
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> The orator of the day, Professor Louis Favre, . . . recalled all these works of Agassiz's. . . Especially when the orator spoke of the "glacial theory" did he interest all his hearers. Venetz, of the Valais, had shown the transportation by glaciers of the enormous erratic boulders which lie all along the valley of the Upper Rhone, and first had the idea of the glacier as the conveyor and carrier of these colossal masses. Then his friend de Charpentier, of Bex, pushing the first idea a step forward, extended the glacier of the Rhone over Lake Geneva, over the Canton de Vaud, and stopped it at the Jura. Then Agassiz came in convinced by de Charpentier that the theory of the ancient extension of glaciers and of the transportation of boulders by ice was based on irrefutable observations; he went further, and at a meeting of the Helvetian Society of Natural Sciences at Neufchâtel on July 24, 1837, over which he presided, in his opening speech, he declared "that there had been a time when glaciers covered the whole area of the Alps, and extended far beyond; that there has been in Europe a period of great cold, a great 'Ice Age' when the mammoths lived."
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> It was a great revolution in science. These words on the existence of a "glacial epoch" raised a tremendous tempest. His adversaries present at the meeting were Leopold von Buch

and Elie de Beaumont, two of the greatest geologists of the first half of this century, and the greatest advocates of the currents of mud and the transportation of erratic blocks by geological floods of prodigious and incalculable force. Endless discussions followed, but the Rubicon was crossed, and it was at Neufchâtel that first dawned the idea of this "Great Glacial Epoch," which little by little, by means of the accumulation of observations in almost all parts of the globe has confirmed the view of the president of the Helvetian Society of Natural Sciences in 1837.

. . . at last Agassiz had the happiness before dying of seeing his theory of a "glacial epoch" accepted by all—even by some of his most constant adversaries, like Sir Roderick Murchison, who wrote to him in 1863 excusing his long opposition. It was but justice. Agassiz by a stroke of genius had seen and seized with a single glance a whole period in the history of the earth—a period till then entirely unknown to all; and, regardless of opposition, he had bravely proclaimed it before the scientific world, certain beforehand that this idea must prevail.

In 1846 a commission from the King of Prussia took Agassiz to America and gave him the opportunity of substantiating his glacial theory, as he had from the beginning expected that an examination of the geology of North America would do. He explored the country for evidences of ice action from the Atlantic Coast to the Rocky Mountains, from the Great Lakes to the Gulf of Mexico, and found erratic blocks, polished and striated rocks, and terminal moraines everywhere north of the thirty-fifth parallel, which forms the northern boundary of South Carolina, Georgia and Mississippi, and cuts into approximate halves Arkansas, Oklahoma, Texas and New Mexico. These phenomena he fully described in his book on Lake Superior. Agassiz was clearly convinced of the universality of the glacial theory and believed that an investigation of the Southern hemisphere would bear him out in this belief. In 1865 a trip to Brazil with his wife and sixteen scientific assistants, financed by Mr. Nathaniel Thayer, of Boston, and Don Pedro, emperor of Brazil, fulfilled his convictions and made more familiar to Agassiz the strange tropic forms which had voiced his first bid for fame.

The journey to Brazil[3] lasted sixteen months and Agassiz came back from Rio de Janeiro and Cairo with renewed enthusiasm and with a firmer hold on his frequently expressed belief in the diversity of the origin of animals and of the human race. The geographical distribution of animals indicated to his mind that distinct zoological provinces are each characterized by peculiar fauna and therefore that animals do not originate from a common center, nor from a single pair. The same theory held true for him in the races of men, which in their natural distribution cover the same ground as the zoological provinces; he believed there to be every reason to suppose that the races originally appeared as nations in the regions they now occupy. There was no room in his hypothesis of special creation and cataclysmic destruction for the modern interpretation of the migrations of animals, peoples and cultures in succeeding geologic epochs. But there was room for speculation and growth in his theory of the classification of forms. A true classification of the multiple forms of life was to be found, in Agassiz's opinion, in an unfolding of the original plan of creation. Not physical causes but the direct intervention of the Creator, he thought, alters or wipes out these forms. With Cuvier and certain of the naturalists and many of the natural philosophers of the eighteenth century,[4] Agassiz believed that nature presents a progression of series from the lowest to the highest types of animal life, culminating in man, but that it is not a uniform progress upward from one type, rather a progress of separate units created as links in a chain, bearing some resemblances but

[3] Described by Mrs. Louis Agassiz in a volume entitled, "A Journey to Brazil."

[4] See Henry Fairfield Osborn, "From the Greeks to Darwin."

not derived from each other. So Agassiz contributed two pillars to evolution, as expressed by Professor Joseph Le Conte:

> I think it can be shown that to Agassiz, more than to any other man, is due the credit of having *established the laws of succession of living forms* in the geological history of the earth—laws upon which must rest any true theory of evolution. Also to him, more than to any other man, is due the credit of having *perfected the method* of comparison by the use of which alone biological science has advanced so rapidly in modern times.

Life and Influence in America

We may now return to the last years of Agassiz's life in Europe and his arrival in America. During the struggle to establish the glacial theory, Agassiz was equally engaged in establishing himself as a teacher of zoology, as a master of the lore of Mollusca and Echinoderms as well as fishes. His driving will to learn and to expound, and his habit of collecting living and fossil plants and animals in every available cranny of his house might have made a less sociable man in a recluse who was "just a bit queer." Agassiz was gregarious. He attracted people easily and he loved doing it. He had been born in Motier, a little village in the Canton of Neufchâtel on May 28, 1807, in a little Huguenot parsonage, where his father, Jean Rodolphe Agassiz, was rector. His mother, Rose Mayor Agassiz, was the daughter of a physician of a neighboring village, and had a brother, also a physician and Louis's early benefactor in Neufchâtel. So Agassiz's advent in the university chair of natural history was really a home-coming, he was among friends and quickly made the beginnings of a teaching reputation. He also was married in October, 1833, to Cècile Braun, the sister of his friend, Alexander, and settled down in a small apartment as an apparently permanent fixture. There his three children, Alexander, Pauline and Susan, were born. Mrs. Agassiz possessed decided artistic talent and had been occupied before her marriage by illustrating her brother's books. Zoology proved an equally good medium for her and she made many of the drawings in her husband's monographs of the period, "Monographies d'Echinodermes vivants et fossiles," "Etudes critiques sur les Mollusques du Jura et de la Craie," "Recherches sur les Poissons Fossiles" and "Fossil Fishes of the Old Red Sandstone."

With his natural gift of making people fond of him, Louis Agassiz had won the liking of Charles Bonaparte, Prince of Canino, himself an enthusiastic scientist. Bonaparte had for several years planned a scientific journey to the United States and had persuaded Agassiz to go with him. Baron von Humboldt favored the proposal and obtained for his friend a grant of 15,000 francs from the King of Prussia in order to prolong the journey. To this Sir Charles Lyell added arrangements for a course of lectures on the "Plan of Creation" especially in the animal kingdom, to be delivered by Agassiz before the Lowell Institute of Boston. But in 1846 Bonaparte was unable to make the journey, so Agassiz departed from Switzerland alone, leaving his young son, Alexander, at school in Neufchâtel and his wife and daughters with the Brauns at Carlsruhe.

He arrived in Boston in September, a European of fabulous learning, author of profound books, among them the scientifically discussed "Études sur les Glaciers," a professor from foreign universities, and as he walked upon the platform and started to speak in broken but earnest English, a very charming man. Agassiz in turn was cheered by the deep attention and warm welcome of his audience, whose heterogenous mixture of rich and poor, seated side by side in lottery-won seats, amazed him.

He and his audiences got along beautifully together and after completing his course on the "Plan of Crea-

tion," he undertook one on glaciers, also in Boston, which was equally successful. The year ripened to summer, and Agassiz lived at East Boston in a little house with Count François de Pourtales, E. Desor and Jacques Burkhardt. He made excursions in Massachusetts Bay with Superintendent Bache in the United States Coast Survey steamer, *Bibb*, and longer journeys to visit scientists and strange localities. The following winter he lectured in Boston and other cities, while three events occurring in quick succession bound him to the United States for the remaining twenty-six years of his life.

In February, 1848, the French republic was declared, and republicans arising swiftly in Neufchâtel, which had been a dependency of Prussia, carried the canton into the Swiss confederacy. Louis Agassiz's income from the King of Prussia honorably, but finally, ceased. Mr. Abbott Lawrence fortuitously appeared, inspired by his interest in the Lawrence Scientific School which he had just founded at Harvard, and offered Agassiz the chair of natural history. Agassiz accepted and took up his abode at Cambridge, where he soon had the pleasure of welcoming his countrymen, Arnold Guyot and Leo Lesquereux. His wife died about this time, and Agassiz's European ties, except with his mother and children, were practically broken.

The Harvard professorship gave him freedom in which to develop his method of teaching from nature, and to collect many more of his precious specimens. He began writing and publishing in English, joined the American Association for the Advancement of Science, and very soon sent for his thirteen-year-old son, Alexander; the following year, 1850, his second marriage, with Eizabeth Cabot Cary, a talented Boston woman, and the arrival of his two daughters from Switzerland completed his domestication.

He had become interested in coral reefs during the winter of 1850–1851, while executing a commission of the Coastal Survey to investigate the nature of the Florida keys, reefs and channels with their relation to the hummocks and everglades of the mainland. His report gave the Coastal Survey much valuable information concerning the maintenance of channels, placing of signals and construction of lighthouses, and widened Agassiz's interest in the life of the sea. The following two winters he spent at Charleston, sandwiching a course in the Medical College in between the autumn and spring sessions at Harvard and thereby considerably saving the strength he had taxed during that interval in former years to augment his income by lecture trips. At the close of the first winter he was informed of the award to him of the coveted Cuvier prize for his "Fossil Fishes." During the second winter at Charleston he fell dangerously ill of a fever and upon his recovery resigned his professorship at the medical college. He was then forty-six years old.

Agassiz next tried his skill at the education of girls as well as boys, teaching natural science in a young ladies' academy, conducted by his wife and daughters at Boston from 1853 until 1863. This in addition to his university work and his researches.

A Creator of Museums and Laboratories

In perfecting his method of comparison Agassiz had turned every house in which he had ever lived into a museum. His grandfather had given storeroom to stuffed birds, shells, bottled fishes and snakes, dried plants and old bones for years, until they had finally been housed in the Lyceum at Neufchâtel, valued by their collector at several thousand dollars. There they remained when Agassiz came to America, but his habit of collecting persisted and first the house at East Boston while later, after his second marriage, an old boathouse on the

banks of the Charles River served as storehouse for all the treasures except a live eagle and bear whose subsequent history is obscure. By 1850 the mere preservation from destruction of many of these had become a severe drain upon his income and they were moved again —to a wooden building on the college grounds, where a grant of four hundred dollars a year kept them from harm, provided fire did not kindle in their flimsy shelter and ignite the alcohol in which so many of them reposed. They were secured very shortly as a permanent part of Cambridge by a subscription of twelve thousand dollars raised by friends of Louis Agassiz. He in the meantime collected more specimens, storing them in his Cambridge home and at his summer cottage in Nahant.

But mere accumulation was not Agassiz's goal. He dreamed of a museum where collections would be arranged to show the relation of each part of the animal kingdom to every other, so that it might be a potent means of training teachers of science, of awakening students and of enlightening the general public. In this institution he would have laboratories for special students with abundance of duplicate specimens and all the necessary appliances of research; he would also have a library. He attained his dream. In 1858 Mr. Francis C. Gray, to whom Agassiz had outlined his scheme, died leaving a fund of fifty thousand dollars for the establishment of a Museum of Comparative Zoology. A grant of lands worth one hundred thousand dollars was obtained from the Legislature of the State of Massachusetts, Harvard College gave an ample site for a building, and seventy thousand dollars additional funds were raised by private subscription. The projected building was planned to form three sides of a square, the main structure to be three hundred and sixty-four feet long and the wings two hundred and five feet each. Of this plan a section eighty feet long was built in 1859–60 and the museum opened its collections to the public and its laboratories, presided over by Agassiz, to students. From the beginning a bulletin was published, which showed each year that Agassiz found more than enough to occupy him, yet was always ready to welcome further development of his museum. He worked on during the civil war, confident that the country would come through the storm, watching his students go off to war, eager in his explanation of American affairs to his British correspondents, and in the darkest hour of the war he became a citizen of the United States and helped to found the National Academy of Sciences.

In 1869, shortly after his mother's death, Louis Agassiz collapsed; his brilliant overworked mind refused to maintain its killing pace. He retired to Deerfield, Massachusetts, and rested from all mental labor for almost a year. Then he returned to Cambridge with renewed vigor and in December, 1871, set out, at the invitation of Professor Benjamin Peirce, of the United States Coastal Survey, to cruise from Boston to San Francisco in a deep sea dredger, the U. S. S. *Hassler*. Mrs. Agassiz, Count de Pourtales, Dr. Franz Steidachner, and a young student, J. H. Blake, all of the museum staff, accompanied him. The trip was highly satisfactory and Agassiz was ready upon his home-coming in October, 1872, to undertake a new project his students had evolved in his absence. This was for a summer seashore laboratory, where teachers from schools and colleges could spend their vacations in the study of nature. No means of carrying out this proposal was in sight; Agassiz appealed to the Massachusetts Legislature and received the newspaper publicity due a man whose name was known to practically every school child and to every American teacher of nature study, to captains of fishing smacks and of ocean liners who put to sea carrying

collector's cans for the museum, to the cultivated audiences of lecture courses and to small academies, to geologists and mineralogists and through them to coal operators and iron smelters, from Boston—in cities fired by his personality to an interest in a subject hitherto considered dry and without profit—two months' journey westward to San Francisco and from Maine to New Orleans. Mr. John Anderson, a wealthy tobacco merchant of New York, read the appeal and was moved to offer for the school his island of Penikese, lying at the entrance of Buzzard's Bay, together with a furnished dwelling and barn thereupon. Scarcely had the offer been accepted when Mr. Anderson added an endowment of fifty thousand dollars and so the school was opened in July, 1873, with Louis Agassiz as director, and Burt G. Wilder, of Cornell University, Alpheus S. Packard, of Brown, and Arnold Guyot, of Princeton, as assistant professors. A yacht for deep-sea dredging was presented the school by Mr. Charles G. Galloupe and placed in charge of Count de Pourtales.

All went well, but in the autumn Agassiz was again worked out. He returned to Cambridge in poor health, working with the grimness of exhaustion. In the middle of a December afternoon he went home, complaining of weariness. Eight days later, December 14, 1873, he died. He was buried at Mount Auburn in a grove of Swiss pine trees with a boulder from the Aar glacier as his monument. Agassiz was a pioneer, a hewer of rough paths, but he taught accuracy, painstaking even tedious comparison, observation of the actual forces of nature at work and quiescent, even though such study involved physical hazard to the student. To get at the truth and disclose it was his great objective and something of that spirit has impressed itself on the school of scientific research which he founded in the United States. John Greenleaf Whittier, not a scientist himself but a friend of Agassiz, caught a measure of Agassiz's purpose and method in a poem called "The Prayer of Agassiz" written to commemorate the opening of the school at Penikese:

> We have come in search of truth,
> Trying with uncertain key
> Door by door of mystery; . . .
> As with fingers of the blind,
> We are groping here to find
> What the hieroglyphics mean
> Of the Unseen in the seen,
> What the thought which underlies
> Nature's masking and disguise,
> What it is that rides beneath
> Blight and bloom and birth and death.

Agassiz's American Students

"Read nature, not books," said Agassiz, adding "If you study nature in books, when you go out-of-doors you can not find her." Upon this principle of observation he built up his school, a practical institution dealing in reality, which maturing in America at an opportune moment in our national history directly or indirectly brought us our first seashore laboratories, many of our great natural history museums—among them the American Museum of Natural History, the Cambridge Museum of Comparative Zoology and the Peabody Museum of Salem, Massachusetts—as well as countless university departments of natural science and a flourishing group of explorers of the life of the ocean.

Practically every distinguished biologic American of the fifties, sixties and seventies was a friend or student of Agassiz's. The roster is bright with accomplishment, even to-day. A diligent search in the memories of J. Walter Fewkes, of the Smithsonian Institution, and David Starr Jordan, president of Leland Stanford Junior University—two surviving Agassiz students—supplemented by early reports of the Museum of Comparative Zoology, yields, the following great, although incomplete, list:

Alpheus Hyatt, of Cambridge; William H. Brewer, of Yale; A. H. Verrill, of Yale; J. Walter Fewkes, of the National Museum; Ed-

ward S. Morse, of the Salem Peabody Museum; Alexander Agassiz, of Cambridge; H. James Clark, of Cambridge; F. W. Putnam, of the Cambridge Peabody Museum and the American Museum of Natural History; Samuel H. Scudder, of the Harvard Museum; Burt G. Wilder, of Cornell, and William James, the psychologist.

N. S. Shaler, of Harvard; John McCrady, of Sewanee, Tennessee; J. Henry Blake, hydrographer, of Cambridge; Count Pourtales, of Cambridge; Theodore Gill, of the Smithsonian Institution and the Library of Congress; Theodore Lyman, of Cambridge; J. A. Allen, mammalogist and ornithologist of the American Museum of Natural History; William K. Brooks, of the Johns Hopkins; Walter Faxon, of Cambridge; Charles S. Minot, of Boston; C. O. Whitman, of Clark University and the University of Chicago, and David Starr Jordan.

E. A. Birge, of the University of Wisconsin; Samuel Garman, icthyologist of the Cambridge Museum; Alpheus S. Packard, of Brown University; Charles Stimpson, of Chicago University; T. B. Stowell, of the Cortland State Normal School; P. R. Uhler, of the Baltimore Peabody Institute; S. M. Buck, of Cambridge; Harland Ballard, of Lenox Academy; Joseph Bassett Holder, of the American Museum of Natural History; Joseph Trimble Rothrock, of Philadelphia; Sidney I. Smith, of Yale, and Henry A. Ward, of Ward's Natural Science Establishment.

Frederick H. Snow, chancellor of the University of Kansas; W. O. Crosby, of Boston; Ernest Ingersoll, author of scientific books; Orestes St. John, of the Canadian Geological Survey; C. Fred Hartt, of Cornell and Brazil; S. V. R. Thayer, of Boston; Caleb Cook, of the Salem Peabody Museum; Charles Foley, ornithologist of Canada; Henry Wheatland, of Cambridge; William Glen, of Cambridge; William N. Rice, of Middletown, Connecticut, and General Albert Ordway, of Richmond, Virginia.

William H. Niles, of Massachusetts Institute of Technology; Albert S. Bickmore, founder of the American Museum of Natural History; F. A. Sherrif, of Boston; Edwin Norton, entomologist of Farmington, Connecticut; S. R. Jillson, of Judson, Massachusetts; W. J. Beal, of the Lansing (Michigan) Horticultural and Agricultural College; T. P. Chandler, of Cambridge; Richard Bliss, of Cambridge; Samuel Lockwood, archeologist and geologist of Freehold, New Jersey; J. B. Perry, of Cambridge; Francis Sanborn, of Andover, Massachusetts, and occasionally Edward Drinker Cope.

Edward Burgess, of the Normal College of the City of New York; E. T. Cresson, of Philadelphia; C. W. Bennett, of Holyoke; Edwin Bicknell, of the Salem Essex Institute; J. H. Emerton, of Boston; E. P. Austin, of Cambridge; E. C. Howe, of Yonkers, New York, and Horace Mann's sons, Benjamin P. and Horace.

The Museum of Comparative Zoology at Harvard University opened its doors under a grant secured by Agassiz from the Massachusetts Legislature and with the additional financial support of Mr. Francis C. Gray, of Boston, in 1859. Nineteen students of the Harvard classes in zoology at the Lawrence Scientific School were enrolled as students and assistants. This number had increased by 1872 to one hundred and three, but the civil war intervening in 1861 had called many of the young men to the armies of both North and South. The early museum reports consequently contain incomplete references to men, later lost sight of or occasionally accounted for in such notes as: Craigin, died in the army of fever. Other names without subsequent clues of identity are: Hansen, M. Gugenheim, Edward King, N. Bowditch, C. A. Shurtleff, J. H. Fowler, John Bartlett, S. C. Martin, Louis Cabot, A. R. Crandall, J. Boll (a young Swiss), Wing and W. J. Hubbard.

The encouragement of women students bears witness of Agassiz's open-minded attitude toward the world and education. A number of young women worked in the library and in the preparation departments, cleaning and mounting fossil bones and shells, classifying and arranging exhibits. Undoubtedly their maiden aunts decried the evil influence of the civil war on the younger generation, but the fact that they did a good job stands in the museum records amid frequent references to Miss Slack, the librarian; Miss Annie Cutler, and the Misses Atkinson, Harris, Clark and Cook.[5]

[5] Miss Susan K. Cook was later in charge of the senior grade at the Packer Collegiate Institute, and made a very good record as a science teacher there.

Each of these students imbibed something of Agassiz's method of teaching from observation rather than by rote, from his impatience with the old rock-bound college curriculum of classical learning whether it suited the individual or not, and his consequent championing of the elective system, and from his firm belief:

> *It can not be too soon understood that science is one; and that, whether we investigate language, philosophy, theology, history or physics, we are dealing with the same problem, culminating in the knowledge of ourselves.*

Agassiz like his contemporaries who enjoyed his influence, Samuel Dana of Boston, J. S. Newberry of Columbia University, Arnold Guyot of Princeton and Joseph Leidy of Philadelphia, did not welcome the invading theories of Charles Darwin. But Agassiz, Newberry and Leidy paved the way in their students' minds for a conception of evolution as far-reaching as any Darwin advanced. Agassiz in his titanic researches of ancient and present-day life of the sea, lake and stream, through the vistas of geologic time in his glaciation theory, and in his insistence upon direct observation of nature supplanted the provincial by the universal conception of Creation in his students' minds and gave time and space to a previously finite world.

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CONTINUOUS FOREST PRODUCTION AS A SOLUTION OF AMERICAN FOREST PROBLEMS

By Professor A. B. RECKNAGEL

CORNELL UNIVERSITY

LAST summer David T. Mason, forest engineer of Portland, Oregon, appeared before the directors of the National Lumber Manufacturers' Association with a remedy for the over-production and consequent depression of the lumber industry. In brief, Mason's proposal[1] is that to meet the net annual depletion of thirty-seven billion feet of softwood timber, which will exhaust our virgin supplies in thirty-seven years, we must stimulate production—not of lumber but of growing forests. He sums up:

> Reasonable changes in government policy, together with the earnest study of possibilities by the principal private timberland owners, will result in the wide introduction of sustained yield forest management, which will solve the problem of American timber supply, the problem of communities dependent upon the forest industries, and will bring prosperity to the forest industries.

This is a "large order." What is sustained yield that it can work such miracles? It is, in brief, to harvest only the amount of timber which is replaced by current growth. The term "continuous forest production" is less technical and carries the meaning better of *keeping the forests productive.*

At present this growth (for softwoods) is only six billion feet annually, as against a depletion of forty-three billion feet annually (of softwoods). At first glance this seems like a hopeless proposition, but an analysis by regions points the way to bring it to pass.

Eastern United States (east of the Rockies): Here the cut is declining rapidly. The net annual depletion is seventeen billion feet. At the end of ten years, lessened cut and more forestry practice will reduce this net annual depletion to eight billion feet. By 1946 regrowth and lessened cut should balance, so that with a harvest of seven billion feet yearly there would be no further depletion—in other words, *sustained yield* would have been accomplished for the softwoods.

Rocky Mountains: Largely in public ownership, the timber in this region is increasingly managed for sustained yield, so that the present net annual depletion of two and one half billion feet will disappear and the cut be stabilized at what the forests can continuously produce.

Pacific Coast States: The three states —Washington, Oregon and California —together with parts of Idaho and Montana, present the nub of the difficulty. Here are the figures:

Present cut	18	billion feet	
Present timber stand	1,080	"	"
Annual cut on sustained yield	$16\frac{1}{2}$	"	"
Net change (decrease in cut)	$1\frac{1}{2}$	"	"

The greatest decrease would have to be in northwest Washington, the greatest increase in southwest Oregon. How can this be brought about? Mason answers:

[1] *Journal of Forestry,* October, 1927, reprinted in the Commonwealth Review of the University of Oregon, October, 1927. See also reports in current issues of lumber trade journals.

It is not expected that everyone, or even a majority, will adopt sustained yield; but with government cooperation it is believed that a sufficient number of important producers, who find it economically practicable, will within a few years voluntarily adopt sustained yield and will thereby effectively apply the brakes to production.

Sustained yield is making advances in the Southern states where the reserve supply, in the form of second growth, is not so heavy a financial load as in the west. Action of private owners by themselves in this direction in the west is harder because of the relatively large amounts of old growth timber as compared with second growth. Therefore, in the west especially there is great need for public cooperation in carrying the timber burden. The solution of the problem in the critical Pacific Coast states will help enormously everywhere. A solution in the west becomes constantly more practicable as cutting reduces the proportion of private timber to the publicly owned timber, provided the public is willing to cooperate with its timber.

Mason concludes that the future market demand of thirty-seven billion feet of softwood yearly will be met, on a sustained yield basis, as follows:

Eastern states	10	billion	feet
Rocky Mountain states	2	"	"
Pacific Coast states	14	"	"
Alaska	1	"	"
Total	27	"	"

Deficit of production ten billion feet, to be met chiefly by closer utilization and by materials other than wood.

Mason's proposal has engendered much discussion. It is not to be lightly discarded as theoretical and impractical. Colonel Greeley, chief of the U. S. Forest Service, in his annual report for 1927, says we must "recognize that the general reorganization of our forest industries around the sustained yield conception is necessary, that its accomplishment is the great goal to be sought."

He goes on:

Sustained yield is, of course, the underlying idea and essential aim of all forestry. We shall not have solved our national problem until the country as a whole is on a sustained-yield basis, with timber production balancing current use. To the individual lumber or paper or other forest industry the sustained-yield conception offers the most rational basis for stabilizing an enterprise throughout. If the forest industries of the west, where large quantities of virgin timber are still available, could forthwith be placed on a sustained-yield basis, the current output of forest products would not be materially curtailed but expansion would be held down, overproduction would be cured at its source, and a rational stability would be introduced into all phases of industrial planning.

Gains in Private Forestry Practice

There are 242 million acres of forest land in industrial ownership. On only one tenth of this area is there, to date, some practice of forestry[2]—equally divided, by area, between the North Atlantic, the southern and the western states. Lumber companies, however, practicing some form of forestry make up *only* three fifths of the area on which forestry is practiced.

The reports submitted at the Commercial Forestry Conference in Chicago in November last, show an effort on the part of owners to facilitate the establishment of a second timber crop. This is, in itself, highly commendable, and it is the first step towards sustained yield or continuous forest production.

Further analysis, however, shows that the situation is not so rosy. As long as the virgin supplies last (especially with present stimulation of over-production) it is not likely that sustained yield management will receive serious attention. A few far-seeing lumbermen may do so, but they will be in the minority. The economic processes now in full swing will continue unchecked as far as present indications go.

When the virgin timber is gone, recourse must be had to second growth. It is over-optimistic to think that our wood requirements can be met from this

[2] See "Progress in Commercial Forestry," Chamber of Commerce of the United States, Washington, 1927.

(*Photos by C. P. Cronk*)

VIEWS IN THE IMMENSE TIMBER STANDS, WEST SLOPE OF THE CASCADES.

source when less than two thirds of the cut-over land is restocking at all and the remainder is practically denuded.

Facing the situation squarely, it seems evident that the output of sawtimber raised *as a crop* will fall far short of our future needs. It is the economic factors —over-production, over-taxation and the forest fire menace—that work to prevent lumbermen from practicing continuous forest production. When an official in Oregon writes: "On the average, the owner will lose less by giving his land to the state now than he will if he finances the growing of a new crop under the general property tax," it is indeed high time to inquire into the tax situation on the Pacific Coast. Fortunately, Oregon has been selected by the National Tax Inquiry for its work in 1928.

The Horns of the Dilemma

The lumber industry, much bedevilled by competition within and without, must apparently choose one of two horns of the far-famed dilemma. One horn is to do nothing—"laissez faire" as the French say—"let her ride" in good American. This is the easiest course and is predicated on the supposition that American inventive genius will find some material to take the place of lumber when our virgin sources of supply are gone. This view is seriously held by many of our citizens and may explain, in part, the apathy which has overtaken the conservation movement. It is undoubtedly true that we live in an age of miracles, but it will require a super-miracle of invention to replace the myriad uses of lumber in an industrial country, such as ours.

The other horn of the dilemma presents a solution which is typical of modern industry—it is to organize for timber growing. There is nothing new in this concept. The timberland owners of the various German states have been organized for years into associations for mutual help and betterment of conditions. They head up in a national association of timberland owners, which is recognized by the central government in choosing the national forest council.

In the United States we are well accustomed to both regional and national organizations among lumber manufacturers, lumber wholesalers and lumber retailers. These organizations are functioning admirably in the improvement of the industry, notably in trade extension under the National Lumber Manufacturers' Association. But so far all the emphasis has been laid on the *merchandizing* of lumber and little or none on the *growing* of lumber. It is true that certain of the associations have widened their scope to include forestry, but it is as an appendage—a "hors d'oeuvre"—rather than as a principal object.

If Colonel Greeley and Mason and the rest of the foresters are right, if the lumbermen who spoke at the Commercial Forestry Conference in Chicago are right, then the time is ripe for a National Organization of Timberland Owners which shall have as its principal function the development of the timber resources on a basis of continuous forest production.

It may be urged that there exists such a multiplicity of associations that any addition thereto is unwarranted. If that be granted, then avoid another association by forming a *National Council of Timberland Owners* (or a "Central Committee of Timberland Owners") whose members shall be representatives of existing organizations like the following:

National Lumber Manufacturers' Association.
American Paper and Pulp Association.
American Railway Association.
Forest Service, U. S. Dept. of Agriculture.
Indian Service, U. S. Dept. of the Interior.

(Photo by C. P. Cronk)

DIFFICULT TOPOGRAPHY OFTEN ENCOUNTERED IN LOGGING RAILROAD CONSTRUCTION IN WESTERN OREGON.

(Photo by C. P. Cronk)

FIRE AFTER LOGGING—THE BANE OF WESTERN TIMBER LANDS.

Organizing for Timber Production

Whatever form of organization is favored, the important thing is to organize forthwith for timber production. There is no time to lose. Mason gives thirty-seven years as the outside figure for softwood supplies—others, less conservative, make it thirty years. Not that there will be a timber famine in thirty years—that idea has long since been discarded—but a time of acute depletion of mature growing timber and a consequent attrition of the forest industries.

A Program of Work

The National Council of Timberland Owners would address itself primarily to the pressing problems that beset timber growing. What these are is too well known to require repetition. Overproduction, taxes, protection from fire, from insects, from fungi, more technical knowledge of how to grow and harvest forest crops—and many more that might be listed—are problems which baffle the individual but yield to united effort. As the late Bolling Arthur Johnson put it, "Cooperation, not competition, is the life of trade."

Foresters should contribute the best technical skill their profession affords in helping owners of timberland achieve continuous production. There are aspects of forest organization and of forest finance with which the lumberman is not generally familiar that might prove very helpful in solving his particular problem. Mason has put this very well:[3]

> The first step toward sustained yield on the part of any forest owner is an earnest, intelligent and thorough study of the possibilities of sustained yield in general and as applied to his own individual situation. A mere superficial and perhaps prejudiced guess on the subject will accomplish nothing—indeed, such action is postively harmful; it is necessary to get the basic facts and interpret them intelligently. To be effective the investigation must be made by some one thoroughly competent to do the work. This is no more a job for anyone inexperienced in this particular field of work than would be the designing of a battleship, the planning of a military campaign, or the conduct of an important surgical operation.

[3] *Ibid.*, p. 39.

(Photo by U. S. Forest Service)

OPERATING LONGLEAF PINE FOR TURPENTINE IN THE FLORIDA NATIONAL FOREST.

(*Photo by T. Colby*)

LOGGING THE SOFT WOODS ONLY DOES NOT APPRECIABLY BREAK THE CROWN COVER IN MIXED FORESTS OF THE ADIRONDACKS.

Conclusion

If what has gone before is an indication of what is to follow, the American lumber industry—yes, the American people, are on the threshold of an important decision. To go on as we have been, using up our remaining resources of virgin stumpage in a final burst of profitless over-production, is to end up at the blank wall of such scanty and comparatively valueless second growth as chance may have produced.

If, on the other hand, the timberland owners organize now, "take arms against a sea of troubles, and by opposing end them," there should follow a period of stability in the forest industries which has not been known before.

The ills of the lumber industry can be cured only at the source, and the source is the timberland. Assured of continuous production of timber in amounts adequate to meet the country's future needs, the present top-heavy enterprise would readjust its processes of manufacturing and marketing with profit to the industry, to the consumer and to the country as a whole. Is not this goal worth the best effort of all lumbermen? Is it not time that the forest land owners who "recognize the national necessity of continuous productivity of their lands when economically feasible" follow the recommendations of the National Conference on Commercial Forestry, and "recognizing their responsibility, assume as a civic duty the leadership in this great national business enterprise, already well begun?"[4]

[4] Quotations from Resolutions adopted at the Commercial Forestry Conference in Chicago, November, 1927.

THE PROGRESS OF SCIENCE

THE FOURTH INTERNATIONAL CONGRESS OF ENTOMOLOGY

By Professor Glenn W. Herrick
CORNELL UNIVERSITY

The Fourth International Congress of Entomology held at Ithaca from August 12 to 18, inclusive, proved to be the most largely attended entomological congress yet held. The total number registering was 515 active members and 110 associate members. Of these, 123 active and 12 associate members, were foreigners representing 38 countries, thus imparting to the congress a truly international tone which was particularly gratifying to all of us who had participated in the organization of the week's activities.

The first contingent of foreign entomologists, headed by Dr. Karl Jordan s cretary of the permanent executive committee, arrived in Ithaca on Saturday, August 11. Early on Sunday morning, August 12, a second group of Europeans arrived and the activities of the congress began in earnest, as two excursions for those interested in collecting had been arranged.

The headquarters and place of registration were located in Willard Straight Memorial Hall, the social center of the students of the university when it is in session, which proved to be almost an ideal building for the purpose. The meetings for the reading of papers and discussions were held mainly in the Baker Laboratory of Chemistry with an overflow of two sections into the Rockefeller Hall of Physics just across the way. Baker Hall, with its main assembly room in which the general sessions were held and its numerous lecture rooms with lanterns, proved convenient for bringing the meetings into a compact area.

On Monday morning the congress opened with a general session in Bailey Hall. By this time over five hundred visiting entomologists had registered who, together with their wives and the local visitors, formed an impressive gathering. Brief and happy addresses of welcome were given by Dean W. A. Hammond, of the university faculty, and Dean A. R. Mann, of the New York State College of Agriculture. These were followed by the address of the president of the congress, Dr. L. O. Howard, who presided in his ever happy and delightful manner. In his address Dr. Howard stressed the importance of entomology in the economy of human activities and urged that more time be given in the courses of zoology in the universities of this country to the teaching of entomology. He gave a fine tribute to Professor John Henry Comstock, who began the teaching of entomology at Cornell as a distinct subject in 1871 and who developed it to its appropriate rank among other zoological subjects through his continuous labors extending over a period of more than forty years. The address of Dr. Howard appears in full in *Science* in the issue of August 17. Following the address of the president, three papers were read by Dr. René G. Jeannel, of France; Dr. Karl Jordan, of England, and Dr. Ivar Trägårdh, of Sweden. Dr. Jordan then gave a brief report as secretary of the permanent executive committee.

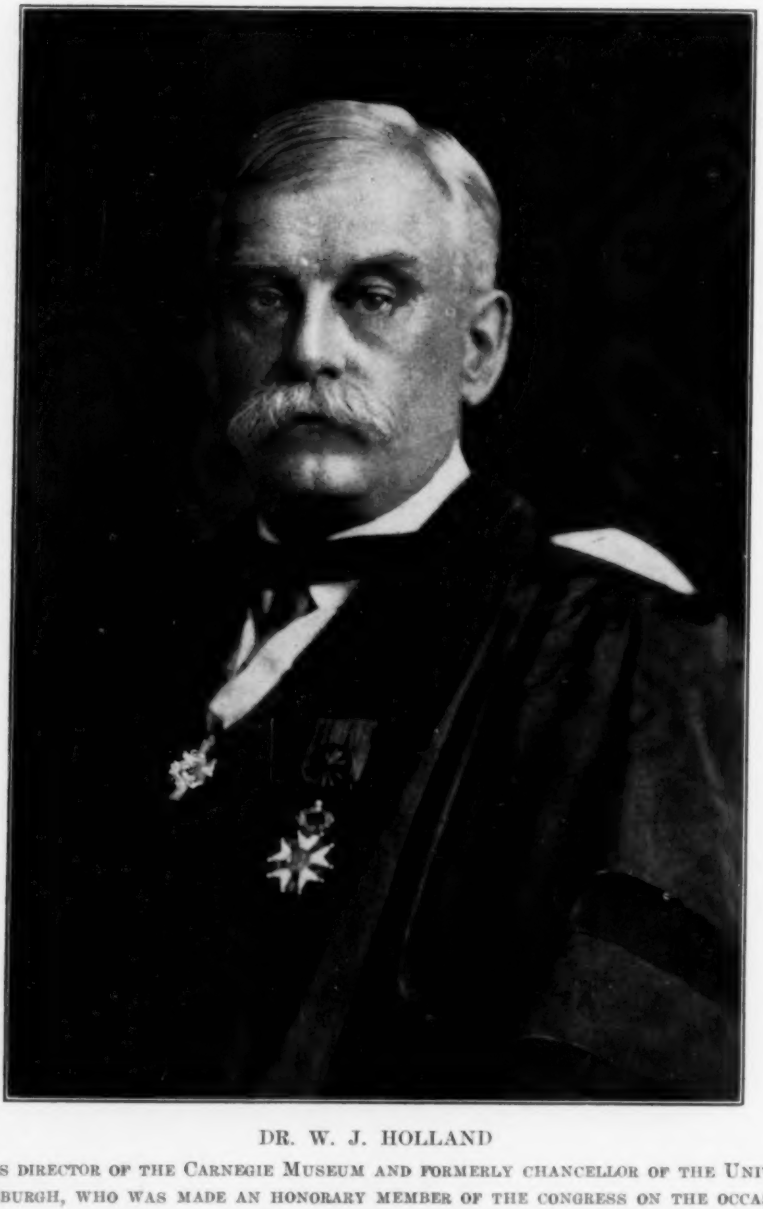
Four general sessions were held at which papers dealing with the broader aspects of entomology were read by representative men from foreign countries and from America. During the afternoons the sections on the various divisions of the science held their sessions. In general, only four or five papers were scheduled for each of these afternoon sessions, thus giving every one an opportunity to return to Willard

ENTOMOLOGISTS OF THE WORLD AT CORNELL UNIVERSITY

In the middle, marked by a small cross on the badge, is Dr. L. O. Howard, president of the congress, surrounded by a group of eminent foreign and American entomologists. At Dr. Howard's left (the reader's right) is Dr. Karl Jordan, of England; next to him is Professor E. L. Bouvier, of France. At Dr. Howard's right is Dr. Filipo Silvestri, of Italy; next to him is Professor W. M. Wheeler, of Harvard University. Sitting in front of Professor Wheeler is Dr. W. J. Holland, at whose left is M. Cameron, of England, and next to him Dr. J. P. Kryger, of Denmark. Standing between Dr. Jordan and Professor Bouvier is Dr. James Waterston, of England. On his right are D. D. de Torres and G. Ceballos, of Spain.

PROFESSOR J. H. COMSTOCK AND MRS. COMSTOCK

PROFESSOR COMSTOCK, NOW IN HIS EIGHTIETH YEAR, INSTRUCTOR AND PROFESSOR AT CORNELL SINCE 1874, WAS ABLE TO WELCOME THE CONGRESS TO THE UNIVERSITY WHICH LARGELY THROUGH HIS INFLUENCE HAS BECOME THE CHIEF CENTER OF ENTOMOLOGY IN AMERICA. MRS. COMSTOCK, ALSO NOW PROFESSOR EMERITUS, IS DISTINGUISHED FOR HER CONTRIBUTIONS TO NATURE STUDY.



DR. W. J. HOLLAND

EMERITUS DIRECTOR OF THE CARNEGIE MUSEUM AND FORMERLY CHANCELLOR OF THE UNIVERSITY OF PITTSBURGH, WHO WAS MADE AN HONORARY MEMBER OF THE CONGRESS ON THE OCCASION OF HIS EIGHTIETH BIRTHDAY.

PROFESSOR STEPHEN A. FORBES

CHIEF OF THE ILLINOIS NATURAL HISTORY SURVEY, LONG PROFESSOR IN THE UNIVERSITY OF ILLINOIS AND STATE ENTOMOLOGIST, NOW IN HIS EIGHTY-FOURTH YEAR, WHO, LIKE DR. HOLLAND, TOOK AN ACTIVE PART IN THE CONGRESS AND WAS ALSO MADE AN HONORARY MEMBER. WITH DR. COMSTOCK, THEY ARE THE ONLY LIVING AMERICANS WHO HAVE RECEIVED THIS HONOR.

Straight Hall for tea and other social activities.

On Wednesday, the congress moved to the New York Agricultural Experiment Station at Geneva, New York, where the sections on systematic entomology and zoogeography and economic entomology had their meetings in the afternoon, but no general session was held. Instead, during the forenoon, the New York State Horticultural Society with its hundreds of progressive fruit-growers held its meeting, at which Mr. Thomas B. Byrd, of Virginia, gave the principal address. This meeting of the Horticultural Society gave the visiting entomologists an opportunity to see a representative body of fruit-growers and farmers of America. In addition, the U. S. Department of Agriculture, under the direction of L. H. Worthley and R. B. Gray, gave a demonstration of the measures in operation for the control of the European corn borer.

The congress was notable for the large number of foreign entomologists in attendance. For the first time, we American entomologists had an opportunity of meeting in a body our foreign confrères, of talking over with them our mutual problems, and of getting acquainted with them in a social way. It was a wholesome, delightful and memorable experience.

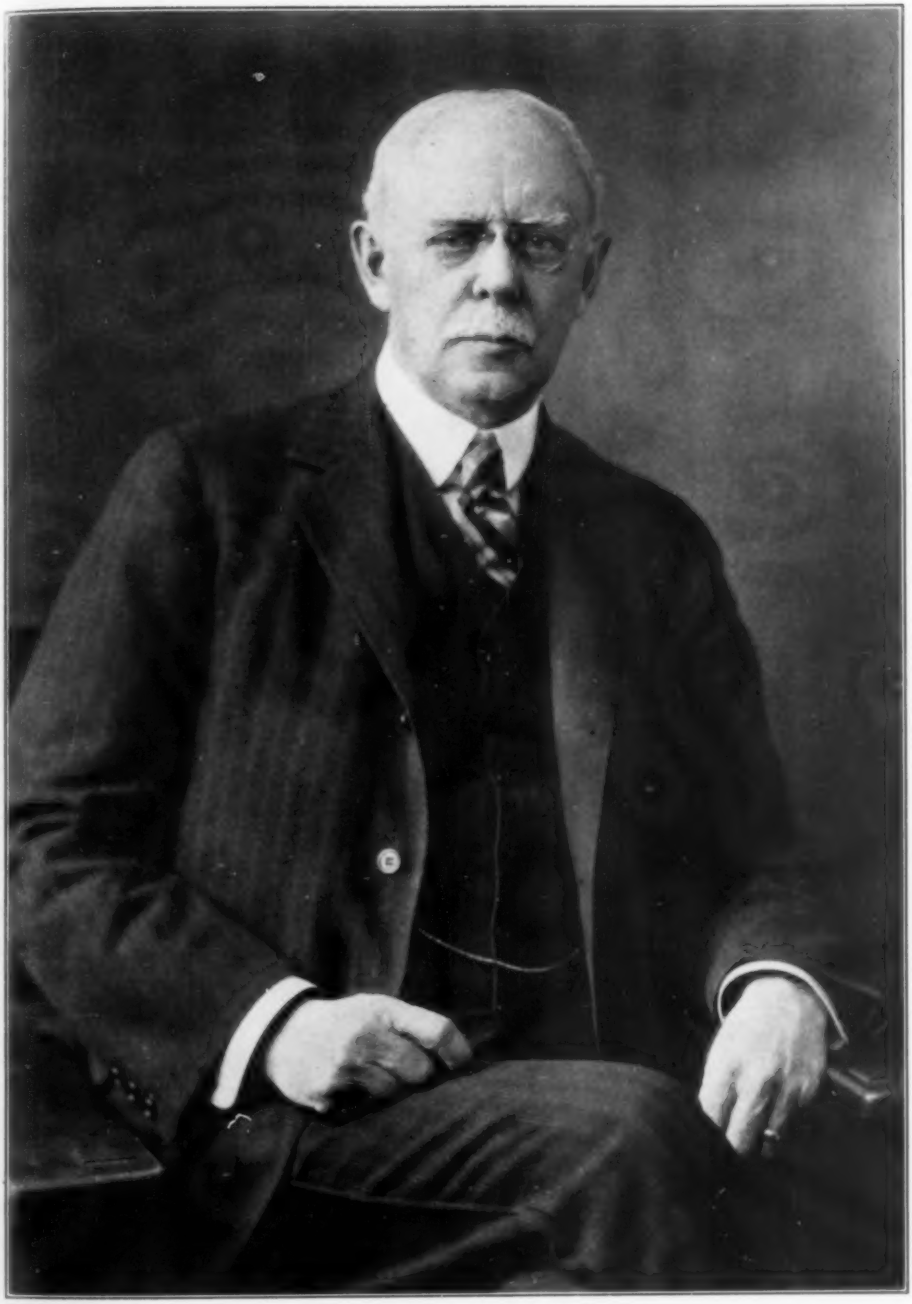
In all about 175 papers dealing with all phases of entomology were read. For the first time, three separate sections devoted to papers dealing with forest insects were organized. The attendance at these sections was unexpectedly large and the interest shown in the papers warrants a continuance of them.

Each of the previous congresses at some time during its meeting has been in the habit of conferring distinction upon certain eminent entomologists by electing them "honorary members of the congresses." In all fourteen individuals have been thus honored. Of these Professor John Henry Comstock, of Ithaca, was the only living American representative. It was therefore fitting that the present congress should follow the action of previous ones in honoring certain eminent entomologists. This the congress did by electing Dr. W. J. Holland, of Pittsburgh, Pa., and Dr. Stephen A. Forbes, of Urbana, Illinois, "honorary members of the congress."

The banquet, which was the concluding social event of the congress, was held on Friday evening, August 17, in the large hall of Willard Straight. Dr. Howard, in the capacity of toastmaster, called upon representatives from thirty-one countries, each of which arose and spoke a few words in his native tongue. At least fifteen languages were spoken in the responses by the different members. In this respect the banquet was unique.

The next International Congress of Entomology will be held in Paris in 1932. It is hoped that a large number of entomologists from Canada and the United States may return the visits of the Europeans and thus renew and continue the acquaintances formed here during the fourth congress. We believe that these opportunities for the coworkers of different nationalities to become acquainted with each other will contribute much toward more friendly intercourse among the scientific men of the various countries represented, and that they will certainly exert their influence toward a more mutual respect between the peoples of the different nations involved.

The effects of the human contacts made during the week at Ithaca, of the intellectual stimulus produced by the exchange of ideas and of the renewed realization that investigators of other countries possess the same human sympathies, desires, wholesome ambitions and sincere devotion to truth as oneself, live on in the mind of every one of us and will continue to exert a widening influence toward a broader respect, tolerance and charity for each other's personality, work and aims.



DR. ARTHUR D. LITTLE

THE DISTINGUISHED ENGINEERING CHEMIST, OF BOSTON, WHO WAS ELECTED PRESIDENT OF THE SOCIETY OF CHEMICAL INDUSTRY AT ITS RECENT NEW YORK MEETING TO PRESIDE AT THE MEETING TO BE HELD NEXT YEAR AT MANCHESTER.

THE BIOLOGICAL EFFECTS OF X-RAYS

Dr. Charles Packard, of the Institute for Cancer Research at Columbia University, has been successful in finding a method by which the biological action of Roentgen and radium radiations can be determined quantitatively. Radiologists have long sought some sort of cell or tissue showing an easily recognized change which varies with the dosage. Among the various kinds of cells which have been tested, the eggs of Drosophila are undoubtedly the best.

Dr. Packard's method consists in radiating some hundreds of eggs, none more than two hours old, and then observing the percentage which hatch out as larvae about two days later. A definite dose kills a definite proportion, which varies in repeated tests within narrow limits. It is seldom that the results of a single test will vary as much as 5 per cent. from the average of all. No other biological material gives results as consistent as those obtained with Drosophila eggs, or which can be repeated at any time.

We have here a means for attacking some problems which have long been a subject of debate. Perhaps the most important is that of the biological action of X-ray beams of different wave-lengths. This is a practical matter for radiologists because they must treat deep-seated diseases with short, penetrating rays, and superficial difficulties with longer, less penetrating beams. If beams of these two qualities have the same intensity will the biological effect be the same or different in the cells which absorb most of the energy?

The experiments with Drosophila eggs appear to answer this question. When the eggs are exposed to homogeneous beams of widely differing wave-lengths and of equal intensity they are killed at precisely the same rate. This is true also for heterogeneous beams. The results of these experiments, involving more than 30,000 eggs, render highly probable the conclusion that the death rate of radiated cells depends only on the intensity of the beam to which they are exposed and the length of exposure.

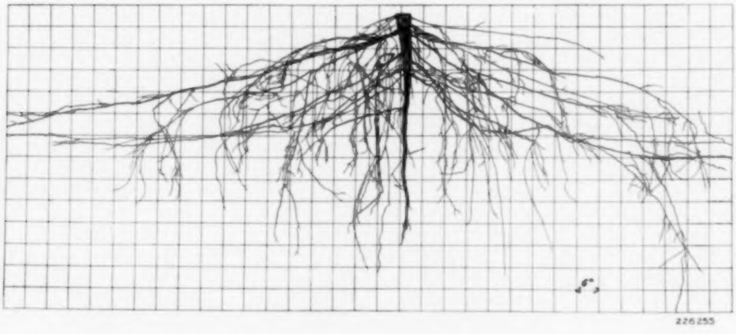
These two factors, intensity and time, when multiplied together, give the number of Röntgen units which have been given. Since the death rate varies with these factors, it is obvious that it varies also with the number of Röntgen units. Many experiments show that half the eggs are killed by 180 of these units. This fact makes possible the measurement of the intensities of the beams. They are found to agree remarkably well with measurements by the ionization method. In one test, the results of radiating the eggs showed that the beam had an intensity of 0.260 electrostatic units per second. The physical measurement showed it to be 0.262 electrostatic units per second.

The method is of practical value, for it permits the radiologist to determine the output of his machines with considerable accuracy without the use of the rather temperamental galvanometer and ionization chamber. Many times when the meters indicate that a definite dose is being given, careful measurement shows that the actual output is quite different. The method is already being used to good effect.

One more problem has been attacked in this way. The direct comparison of X-ray and gamma ray intensities, in terms of Röntgen units, can not now be made by physical instruments, because the ionization chamber which will properly measure the X-ray beam is not sensitive enough to detect the very weak gamma radiation. Dr. Packard believes that Drosophila eggs make the comparison possible. A few tests with the gamma rays of measured intensity will show how long an exposure is required to kill half the eggs.

ROALD AMUNDSEN

THE DISTINGUISHED NORWEGIAN EXPLORER OF THE ARCTIC AND THE ANTARCTIC, WHO LOST HIS LIFE IN THE SEARCH FOR THE ILL-FATED *Italia*.



THE ROOT SYSTEM OF A LONGLEAF PINE

By E. W. Gemmer

Every one in the South is familiar with the tap-root of longleaf pine. We see it in washes, road cuts, clay pits, and almost any place in the woods where soil has been removed. That the pine has a system of lateral roots of almost unbelievable size is probably very much less known.

In undertaking to study the roots of longleaf pine on the Choctawhatchee National Forest, the forest service last winter washed the soil away from around the roots of two longleafs, three inches in diameter breast high and 20 feet in height. The method of washing consisted of playing a stream of water from a fire hose on the sandy soil around the roots of these trees. Due to the sandiness of the soil it was easily moved from the point of contact but immediately settled when out of the direct force of the stream. To remove this loose sand a device based upon the principle of a jet blower was built, whereby a stream of water was shot into a three-inch pipe which sucked the sand into the pipes and deposited it some 60 feet from the "diggings."

The amount of soil necessary to be removed to expose the roots was amazing. The roots of one tree occupied an elliptical area of 150 square feet, the longest axis being 19 feet and the shortest 10 feet. The laterals branch from the tap-root immediately below the root collar and in general occupy a zone from one to three feet beneath the surface. The roots therefore had contact or had access to the moisture and nutrients of approximately 50 cubic yards of soil, not considering the tap-root.

The tap-root was five and a half feet long, stocky, and a firm anchor for the little tree. From this root a few small laterals penetrated the deeper soils not invaded by the major laterals.

When we consider the dimensions of the roots of this small sapling we can well wonder what are the dimensions of a mature longleaf. Examination of several have shown that roots one half inch in diameter are not infrequent at 30 feet from the tree, or twice the radius of the crown at that point.